Geodætes Practicus:

OR, THE

ART OF SURVEYING.

Surveyed and laid out in a more Accurate, Plain and Expeditious Plat, then hath hitherto been performed:

Being a WORKE very uſefull for

Surveyors, Architects, Engineers, Maſons, Carpenters, Joyners, Brick-layers, Glaſiers, Painters, &c.

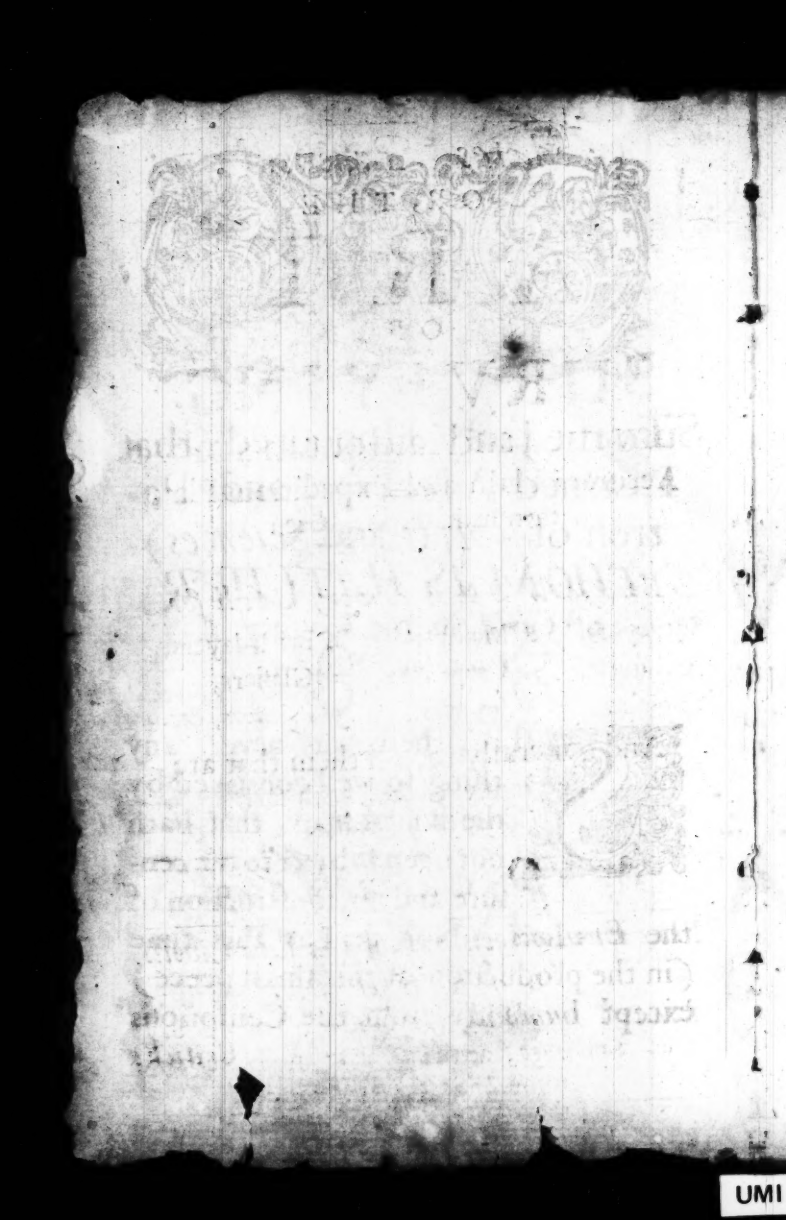
And generally for all them that are Ingeniouſly affected with ſuch kinde of Learning.

By VINCENT WING.

Pro captu Lectoris habent ſua fata Libelli.

LONDON.

Printed by *Wil. Leybourn*, for *George Sambridge*, at the Signe of the Bible upon *Ludgate-hill*, 1664.



To the truly Honoured (that Learned *Mecænas*, and Patron of *Arts* and *Sciences*) *THOMAS HATCHER* of *Carby* in the County of *Lincolne*, Esq;

SIR, there was never any thing so well contrived by the wit of man, that hath not been subject to the censure and misconstruction of the *Envious*. Nor do I at this time (in the production of this small peece) except *Immunity* from the Censorious

Criticks of this present Age; yet for such was this work never intended, but onely for the more Learned and Judicious, whose candid Censures I dare abide. *Nunquam enim doctorum hominum castigationes molestè tuli, sed in hâc imprimis tractatione veritatis, etiam imploro.* But yet not without Labour and Difficulty can Books have passage into the *World*, for (as one well observes) *Librorum fortuna nihil ferè à liberorum conditione dissensit; in his edendis insudat corpus, animus in illis æstuat.* However to the end the Placid Fruit of these my Labours (now grown up amongst the *Wild Grapes* of the Field) may be cherished and preserved from the Turbulent Storms of male, discontented, and detracting Spirits, it now (being come to its Maturity and Perfection) most humbly implores the Protection of some Learned MECEANAS to defend it.

And

And being well assured (SIR) of your most Heroick and Candid Dispositi ion, and more especially of your great Learning, and most Excellent Knowledge in the MATHEMATICAL ARTS and SCIENCES, wherein you have been Exercised even from your Youth; it therefore casts it self into the Arms of your known Humanity for Shelter and Protection, not doubting but that your *Refulgent Raies* shining thereon, will be sufficient to *annihilate* and dispell the most dark and misty Clouds ascending our *Horizon*, which will thereby not a little *consolidate* and *strengthen* both my present and future undertakings for the publique good, and excite the Author to a gratefull acknowledgment of your memorable vertues, and to eccho forth the praises due to your *Name* and *Eminency*, in the words of the *Poet*.

O & præsidium, & dulce decus meum!

SIR, I need not tell you how necessary and beneficiall GEOMETRY is to the *Common-wealth*, whose Excellent and manifold use may challenge an equality with most (if not any) other, and its certainty above all other *Sciences*, in respect of its *pure*, *genuine*, and *infallible Demonstrations*. *Nam cum cetera artes probabili quadam opinione constent, certè Geometria (inter Mathematicas spectatissima) veritatis confirmatione seipsam tuetur & commendat.* All other *Arts*, *Sciences*, and things in the World may be rested and inverted, according to the fancy and will of men. *Hæc autem ipsa suo innixa præsidio, perpetua, simplex, & uniusmodi est; nulla huc controversia, nulla deceptio incidit, quæ non statim ad veritatis fidem, probationemq; referatur; ejus quippe rationes non persuadent, sed cogunt*, saith *Peletarius*. But as for the Excellency of the Art, it's well

well known to your *worthy ſelf.* All that I have endeavoured is to profit others, and to make my *diligent* and *ſtudious Reader* able to benefit his *Countrey* and *Common-weale*, which Certes is no more then the common Law of Humanity requires at all our hands, and not (like ſome) to bury their *Treaſures* in the Aſhes of Oblivion. *Non valet qui ſine ſtudiis vivit*; (ſaith one) *Quin immo otium abſque literis mors eſt, & vivi hominis ſepultura.* Which puts me in mind of that excellent ſaying of *Tully. Non nobis ſolum nati ſumus*, &c. Wherefore (Noble Sir) I have endeavoured (*Quantum fas eſt*) in as plain and *ſuccinct* a *Method* as I could imagine, to lay down the Art of *Surveying* by the *Agrimetricall Table* onely (as being the beſt Inſtrument now known for that purpoſe) and to furniſh the whole Worke with ſuch *Theorems*, and *Problems Geometricall*, as are moſt neceſſary

ceſſary and ſubſervient thereto.

Laſtly, (Sir) ſince you are the beſt able to protect it of any I know, in reſpect of your deep and piercing judgement and knowledge in the *Mathematicks*, I therefore now in all humility commit it to your protection, reſting,

(SIR,)

Your moſt Subject

Servant,

Vincent Wing.

To The

READER.

Courteous Reader,

BEing lately requested by divers of my Countrey-Men, to write something of Surveying, *that might be usefull to the Republick; I did, in a manner, deny their desire, in regard some others have lately written upon that subject, and the rather, because my time is almost continually spent in the practical part thereof: yet to satisfie their importunitits, I adventured to spend a few houres, in compiling the subsequent* Tractate *here presented to thy view; which may be usefull to thee, and serve for thy Pocket-Companion, when thou canst not have the use of a larger Book upon this Subject. True it is, I might have wrote more largely, but perhaps I should then have appeared more intricate, and less profitable:*

fitable: and though I have affected brevity, yet have I throughout proceeded in so plain a Method, that (I doubt not but) the work will be perspicuous to the meanest capacities, for whose sakes alone it was principally intended: neither have I omitted any thing that I thought necessary, or expedient in the least.

And for as much as the Antiquity of the Art *of* Surveying *is very great, (and well known to most) as we may read in the Prophet* Zachary, *Chap. 2. v. 1. where the Prophet saith,* That when he lifted up his eyes, he beheld a Man with a Measuring-line in his hand: *and when the Prophet demanded the Question, whether he went, he said unto him,* He went to Measure *Hierusalem,* to see what is the breadth thereof, and what is the length thereof. *Of such value and estimation was this learning in* Plato's *time, that he would admit none into the* Philosophy-*Schooles, that was not skilfull in* Geometry; *thinking them not capable and fit Auditors: whence was that inscription over the* Philosophicall *Schoole-doores,* ἀγεωμέτρητος εἰσίτω. Let no Man, ignorant of *Geometry,* come within these doores. *Now the end of* Geometry *is to Measure well, and that not onely things upon the* Earth, *but in the* Heavens *above, to be understood by those Glorious Creatures, the* Sun, Moon, *and* Stars; *whose true Motions, Magnitudes, Intervalls, and Distances from the Earth, and amongst themselves, are onely to be known by* Geometry, *whose hand-maid is* Arithmetick; *her inseperable*

rable companion: touching which S. Augustine *saith,* Nemo ad divinarum, humanarumque rerum cognitionem accedat, nisi prius annumerandi artem addiscat. *These* Sciences *then, as they are of singular use and benefit, in all our humane affairs, so are they helpfull to us to unlock many* Mysteries *in* Divine Writ, *which cannot so well be understood without some knowledge therein: but I shall now forebear to instance in particulars, hoping no Man is so maligne, as to think our Labours, in a Work of this nature, to be fruitless or vaine.*

Besides, the utility hereof is as great, as the Science *is ancient; for, what is more necessary in a well-ordered Common Wealth? how can a Man fitly enjoy his owne, or know what he possesseth, without some skill in this* Art, *or the assistance of a* Surveyor; *whose office is chiefly,* Cuilibet dare quod suum est: *to give every Man his own, as well one Man as another: for, as it helpeth the* Lord *to have a true knowledge of his own estate, by a due and accurate* Survey *of the same; so it assures the* Tenant *of his Measure and just due, whereby the* Lord *is neither abused, nor the* Tenant *damnified and grieved by false information; and therefore that common saying, that* Surveying *is bad for the* Tenant, *and causeth him to have hard bargains, by letting the* Lord *know what he holdeth of him, can be nothing but a meere Cavill of some discontented braines. Doth his knowledge either abridge, or wrong his conscience? No sure: tis otherwise*

wiſe in ſuch as are Gentlemen of worth and quality, endued with the light of divine reaſon, and for ſuch terene ſpirits as grove in the Earth, and make that their Mammon, let them awake, and heedfully ſhun and beware of filthy avarice, and oppreſsion of their poore Tenants, *which through the bad examples of ſome men, is now grown one of the greateſt Scars to true honour and reputation, that this latter Age hath produced; whereby that of the* Apoſtle *is fully verified, who ſaith,* That in the laſt dayes, Men ſhall be lovers of themſelves, covetous, boaſters, proud, *&c. as it is* 2 Tim. 3. 2.

Moreover, as the Science *of* Surveying *is Ancient, and profitable, in finding out the true quantity of every Mans* Lands *and* Poſſeſſions, *ſo is it of ſingular uſe in taking the juſt and true dimenſion of all kinde of* Superficies *and* Solids, *as* Walls, Tyling, Glaſs-worke, Floors, Partitions, Wainſcot, Hangings, Ceiling, *and the like: as alſo in menſuring of* Heights *and* Diſtances, Plotting *of whole* Countreys, Towns, *and* Cities, *and in innumerable other matters of greateſt weight and importance, wherein the aid and aſſiſtance of this* Science *is neceſſarily required;* Quid vis amplius?

Beſides, how availeable this Art *is to the common* Artificer, *the ordinary* Maſon *and* Carpenter *can eaſily teſtifie, in the Menſuration of his* Stone *and* Timber, *of what forme and faſhion ſoever it is. This* Science *then being ſo uſefull and commodious,*

brings

brings that saying of the Philosopher *into minde*; Bonum, quo communius eo melius: *Good, the more common, the better it is: and therefore 'tis cheifly that I present thee with this small* Mite, *which may assist thee in the performance of such things as are of no small moment in Mundane affaires.*

But what need I speak further hereof, since the singular use of this Art *is so generally known to the World; and therefore I shall now proceed to give you some account of the following Treatise.*

The first Book consisteth of certain Definitions, *and* Problems Geometrically, *which are laid down succinctly, as the ground and foundation of the whole Work.*

In the second Book is contained the Dimension of plain Triangles, *according to a* Table *of Artificial* Sines, Tangents, *and* Logarithms, *which is of excellent use in finding the superficiall content of all kinde of* Figures; *and in taking of* Heights, Distances, *and the like.*

In the third is contained the mensuration of the superficiall content, or Area of any Figure, Plot, Peece *of* Ground, Map, *or the like: of what forme, fashion, or proportion soever.*

In the fourth is shewn a briefe and speedy way of Reduction, *whereby all manner of Figures may be reduced, from one forme to another, retaining still the same quantity and proportion.*

The fifth Book shews how to divide any Figure

given

given into as many parts as shall be required, and to cut off from the same any quantity whatsoever.

The Sixth Book shews how to Plot *exactly all manner of* Grounds *whatsoever, severall wayes; and to finde the just quantity and proportion thereof, after a more substantiall manner then hath hitherto been performed.*

To which Book is annexed (as an Appendix *to the* Art *of* Surveying Land, *in generall) a convenient and necessary* Tract, *Intituled,* Scalæ Orthographico-metricæ, *&c. or, an* Addition, *&c. to the* Art *of* Surveying, *&c. as may be further seen in its* Title *there. Which coming opportunely to my hands from the* Author *himself, I thought good to make publick here with my own* Work, *as being pertinent and proper to the present Subject.*

In the seventh Book is shewed both Arithmetically, *and by* Tables, *how to Measure exactly all manner of* Walls, Timber-work, Roofes *of* Houses, Tyling, Boords, Glass, Wainscot, Ceilings, Pavement, *and the like; as also* Timber *and* Stone, *of what forme soever.*

The eighth Book contains certain Problems, *both of* Altimetria *and* Longimetria; *whereby all manner of* Heights *and* Distances *may exactly be found out and determined.*

The ninth Book shews how to investigate, and finde out the true distance of any two places upon the Terrestriall-Globe, *from one another, as they are measured*

measured upon the Earths Superficies *in a* Sphæricall-line.

The tenth Book contains certain Rudiments *in* Astronomy, *as a definition of the* Circles *of the* Sphere, *with the manner how to resolve all the most necessary* Propositions *thereunto belonging: Also* Problems *in* Horologiography, *or* Dialling, *and to make* Horizontall, or Verticall Dialls, *either* Direct *or* Declining. *With sundry other* Rules *and* Tables, *to finde the true hour of the Night by the* Sun, Moon, *and* Stars.

Having thus given you a short view of the severall Sections *of this little Book, I shall not make* Apology: *but my desire is, that you would read it thoroughly, and doubt not, but you shall finde as much profit, if you read and practise it, as I have taken paines and delight in composing it for thy use and benefit; and if I finde your candid acceptance hereof, it will incourage me shortly to inlarge my present conceptions upon this Subject. So wishing you a happy progress in all your just endeavours, I rest*

Dat. Luffenhamiæ
Idibus Junii,
1663

Your Friend,

Vincent Wing.

Imprimatur.

G. Stradling S. T. P. in Rever.

in Christo Pat. D. Gilb.

Ex Ædib. Sabaud. Aug. 8. 1664.

Epis. Lond. a sac. dom.

The Art of
SURVEYING.

BOOK I.

IN this Book, are contained all thoſe neceſſary Definitions and Propoſitions Geometrical, which as the Ground and Foundation of the ſubſequent Problems are laid down and propounded in a due and convenient method. And althongh they have already been exceeding well performed by ſundry of our Nation, yet had they here been omitted, the following parts of this Book would appear but dark and obſcure, whereby the Reader ſhould (in a manner) have been wholly deprived of the benefit and fruition of theſe my Labors. And to the end I might not overburden the Book with needleſs curioſities, by inſerting any thing that is not of uſe, I have added onely ſuch Propoſitions, as are moſt neceſſary for my preſent purpoſe.

Geometricall Definitions.

1. *Punctum est, cujus pars nulla:* As Geometricians define it; so that we may account a point to be that small part which cannot be divided, than which nothing can be less, as the point A.

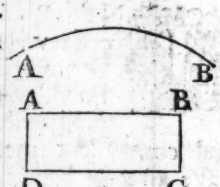
2. *Linea est longitudo latitudinis expers.* A line is a length without bredth or thickness, and is capable of division, being limited by the point before spoken of; and of lines there are two sorts, namely Right, and crooked or Sphærical.

3. *Recta linea est, quæ ex æquo intra sua signa interjacet.* So that a straight line is the shortest extention between two points, as the line A B

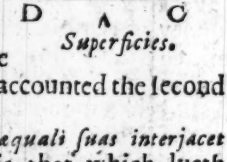
A ——— B

A Sphærical, or crooked line hath compass and is circular, wherein it differeth from a straight line, as

A crooked line



Superficies est, quæ longitudinem latitudinemque tantum habet. Therefore a Superficies is that figure which hath length and bredth, without depth or thickness, the extremes whereof are lines, as A B C D. And this is accounted the second quantity in Geometry.



Superficies.

Plana superficies est, quæ ex æquali suas interjacet lineas. A Plain Superficies is that which lyeth equally between his lines, as the superficies A B C D.

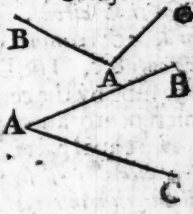
An angle is the congression or meeting of two lines in one superficies, so as they make no straight line, and if the lines that comprehend the angle be right

right lines, then it is called a right lined angle.

Again, angles are of three ſorts, namely Orthogonal or Right, Acute or Sharp, Obtuſe or Blunt. If a right line fall upon a right line, making two equal or right angles, each of thoſe angles are called Orthogonal, or right angles, and the line that falleth upon its Baſe-line is called a perpendicular; as upon the line C D, the line A B doth fall in ſuch ſort, that it maketh the angles on either ſide equal, namely the angle A B C on the one ſide, equal to the angle A B D on the other, which are called right angles, and the line A B falling plumb on the line C D at B is called the perpendicular.

Obtuſus angulus major eſt recto. An obtuſe or blunt angle is greater than a right angle, which is 90. deg. as is to be underſtood by the angle B A C.

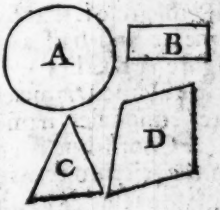
Obtuſe



Acutus verò, minor eſt recto. An acute or ſharp angle is leſs than a right angle, on 90. deg. as is repreſented in this figure by the angle B A C.

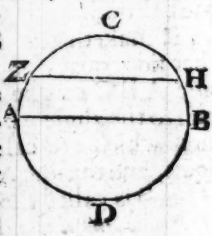
Terminus eſt, quod alicujus eſt extremum. A limit or term is the end of every thing.

Figura eſt, quod ab aliquo vel ab aliquibus terminis comprehenditur. A figure is that which is contained under one limit or term, or many; as in theſe



four figures A B C and D, whereof the first figure A is contained under one right line, which is a circle, the second figure C under three, and the two other B and D under four right lines, and the like of others.

Circulus est figura plana ab una linea comprehensa, quæ peripheria vocatur, &c. A circle is a plain figure contained under one crooked line, which is called the Circumference or Terimeter, as the figure C A D B represents.



Centrum ipsius circuli punctum appellatur. The center of a circle is a point in the middle thereof from whence all right lines drawn to the circumference are of equal length, and are called Semi-diameters.

Dimetiens circuli est recta quædam linea per centrum acta & terminata in utramque partem à peripheria circuli, &c. The Diameter of a circle is a right line passing by the center from one point of the circumference to another, and doth divide the circle into two equal parts, as is shewed by the line A B.

Semicirculus est figura comprehensa à diametro, & per diametrum intercepta in circuli peripheria. So that a Semicircle is that figure which containeth a Diameter and half a circumference; as in the last figure A B C D, which is divided into two equal parts by the Diameter thereof A B, each of which are Semicircles, namely A C B, and A D B.

A Chord-line is a right line drawn from a point in the circumference to another, and toucheth not the center, as the line Z H; wherein observe that

that theſe and ſuch like parts of the circumference ſo divided, are commonly called Arches, or Arch-lines.

Segmentum circuli, eſt figura quæ ſub recta linea, & circuli peripheria continetur. A Segment, Section or portion of a circle, is a figure contained under a right line and part of the circumference, either greater or leſſer than a Semicircle. As in the former circle the figure Z C H being contained under the right line Z H, and the minor part of the Perimeter Z C H, is termed the leſſer Segment or Section of a circle, and the figure Z D H becauſe it is contained under the right line Z H, and the greater part of the peripherie Z D H is called a greater Segment, Section, or Portion of a circle.

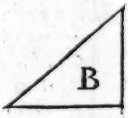
Rectilinea figura, ſunt quæ ſub rectis lineis continentur. Right lined figures are ſuch as are contained under right lines of any number above two, whereof ſuch as are comprehended of three lines, are called Triangles, and in reſpect of their three ſides, they are either *Iſopleuron*, *Iſoſceles*, or *Scalenum*, as namely a Triangle having three equal ſides is Iſopleuron, or equilateral. Secondly a Triangle with two ſides equal, is called Iſoſceles; and thirdly, if it have three unequal ſides, it is called Scalenum.

Again, Triangles are alſo of three ſorts in reſpect of their angles, *viz.* Oxygonium, Orthogonium, and Amblygonium. The firſt of theſe is ſuch a Triangle as hath three acute angles, and therefore called Oxygonium; but the ſecond ſort called Orthogonium, is that Triangle that hath one right angle. And laſtly, the Amblygonium is a Triangle that hath one obtuſe or blunt angle.

Hence it appears that every Triangle hath a double name, and that there are ſeven kindes of right lin'd Triangles.

An equilateral, or Iſopleuron Oxygonium is a triangle conſiſting of three equal ſides and three acute angles, as the figure A.

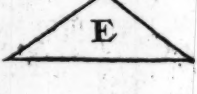
An Orthogonium Iſoſceles hath two equal ſides and one right angle, as the figure B.



An Orthogonium Scalenum hath one right angle, and three unequal ſides, as the figure C.

An Iſoſceles Oxygonium hath two equal ſides, and all his angles acute or ſharp, as the figure D.

An Iſoſceles Amblygonium is a Triangle that hath one obtuſe angle, and two equal ſides, as the figure E.



An Oxygonium Scalenum hath three unequal ſides, and three acute or ſharp angles, as the figure F.

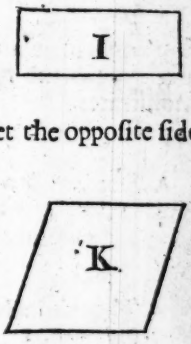
An Amblygonium Scalenum is a Triangle having three unequal ſides, and one obtuſe or blunt angle, as the figure G.

Four

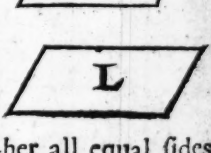
Four ſided figures are of five ſorts, whereof the ſquare challengeth the priority. A ſquare is a figure contained under four equal ſides, and four right angles, as the figure H. or as others define it, 'tis *Parallelogrammum Rectangulum æquilaterum.*

The oblong, or long ſquare (*quod eſt Rectangulum quidem, non autem æquilaterum*, as ſome define it) is a figure contained under four right angles, and four unequal ſides, and yet the oppoſite ſides are equal, as the figure I.

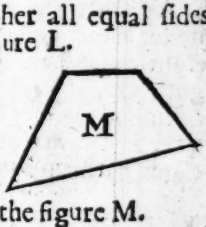
Rhombus eſt figura quadrilatera æquilatera, ſed non rectangula. A Rhombus is a figure contained under four equal ſides, but not right angles, as the figure K.



Rhomboides quod oppoſitis lateribus & angulis æquale, neque æquilaterum eſt, neque rectangulum. A Rhomboides is that whoſe oppoſite ſides and oppoſite angles are equal, yet neither all equal ſides, nor any right angles, as the figure L.



Trapezia ſunt quadrangula non parallelogramma. Hence all other figures of four ſides and four angles, which have neither equal ſides, nor equal angles, are called Trapezias as the figure M.



Multilatera sunt, quæ à pluribus quam quatuor. Many sided figures which consist of more than four sides, are called Poligons, and do every of them receive their names according to the number of their angles, whereof there are two kindes, Regular and Irregular; Regular are such as have both equal sides and equal angles, which are called regular Poligons:

A Pentagon is a figure of five equal sides, and five equal angles, as the figure N demonstrates.

A Sexagon is a figure of six equal sides, and six equal angles, as the figure O.

A Heptagon is that which hath seven equal sides, and as many equal angles, as the figure P.

An Octagon is contained under eight equal sides and eight equal angles, as the figure Q.

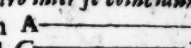
In like manner the Encagon hath nine equal angles, and as many equal sides; and lastly the Decagon hath ten equal sides, and ten equal angles.

Irregular

Irregular Poligons have neither equal side, nor equal angle, as the figure R.

Parallelæ rectæ lineæ sunt, quæ in eodem plano sitæ, & in infinitum utrimque productæ neutro inter se coincidunt.

Parallels are right lines, which being produced infinitely, will never meet in any part, as the right lines A B and C D, which though they was infinitely extended, yet would never meet.

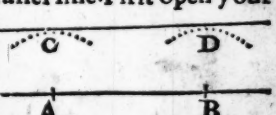


Geometrical Problemes.

Prob. I.

Vnto a right line given, to draw another line, which shall be parallel to it at any distance assigned.

LEt the right line given be A B, unto which it is required to draw a parallel line. First open your Compasses to the distance requ red, and setting one foot in the end of the line at A, with the other make an arch on that side the line whereon the Parallel is to lye, and then make the like arch at the other end of the line B, as the arch lines C and D. Lastly, lay your Ruler by the convexity of those two Arches, and draw the line C D, which shall be parallel to the given line A B, as was required.

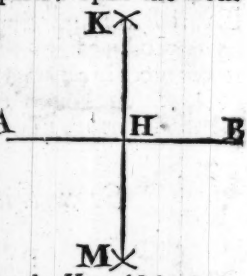


Probl.

PROBL. II.

To divide a line given into two equal parts at right Angles.

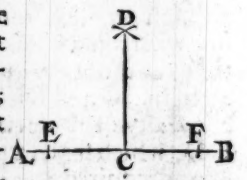
SUppose A B be the line given, which is to be divided into two equal parts; open the Compasses to a greater distance than half the given line, and setting one foot thereof in one end of the given line, with the other draw an arch-line above and below the line given, then (the Compasses unstirred) place one foot in the other end of the given line, and cross the two former Arches in K and M, from which two intersections draw the line K M, which shall divide the line given A B into two equal parts at H with right angles, as was required.



PROBL. III.

From a point in a line given, to raise a Perpendicular.

LEt A B represent the line given, and C the point assigned, whereon it is required to erect a perpendicular; open the Compasses to what distance you please, and setting one foot in the point C,



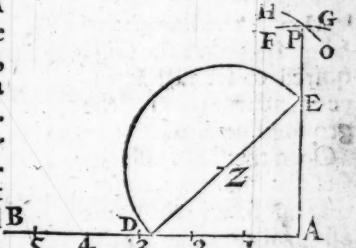
make

make a marke on either ſide thereof at E and F, then open your Compaſſes again to any other greater diſtance, and ſetting one foot in E, make an arch above the line, then remove the foot into the point F (the Compaſſes remaining at the ſame diſtance) and croſs that arch in the point D. Laſtly draw the line D C, which is the perpendicular required.

PROBL. IV.

Vpon the end of a line given, to erect a Perpendicular.

THere are ſeveral ways to effect it, but I ſhall inſtance in two. Let A B repreſent the ground line given, and let A the end thereof be the point aſſigned, whereon to raiſe a perpendicular line. Open the Compaſſes to any convenient diſtance, and ſet one foot in the end of the line at A,



whereupon the perpendicular is to be erected, and make a point with the other above, as at Z, then reſting one foot in Z (the Compaſſes remaining unſtirred) deſcribe the portion of the Circle D E, which cutteth the ground line in D, then lay a Ruler from the interſection D, and the point made above the line at Z, and it will cut the arch line in E. Laſtly, draw the line A E, which is the perpendicular required.

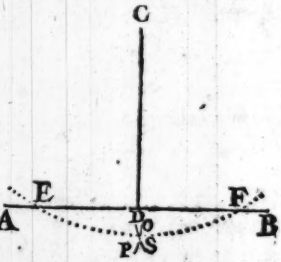
Other-

Otherways, with your Compaſſes opened to any convenient diſtance, make five ſmall diviſions, beginning at A, noted with the Arithmetical figures 1. 2. 3. 4. 5. then take with your Compaſſes the diſtance from A to 4. and ſetting one foot in A, with the other deſcribe the arch F G, then take the diſtance A 5, and placing one foot of the Compaſſes in 3, with the other foot deſcribe the arch H O, interſecting the former in the point P. Laſtly, from P draw the line A P, which will be perpendicular to the given line A B.

PROBL. V.

From a point above, to let fall a Perpendicular, upon a line given.

SUppoſe the line given be A B, and let C be the point above the ſaid line, from whence it is required to let fall a perpendicular upon the ground line A B.



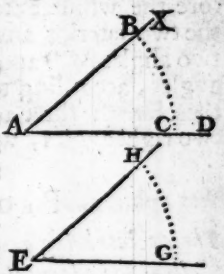
Open the Compaſſes to ſuch a diſtance, that ſetting one foot in the point aſſigned above at C, the other may reach over the ground line, and may deſcribe the arch E S F, then ſetting one foot in E, make the arch O P, that done, ſet one foot in F, and croſs that arch in S, from which point to the given point C, draw the line C S, which is the perpendicular to the line A B in the point thereof D.

PROBL.

PROBL. VI.

To make an angle equal to an angle given.

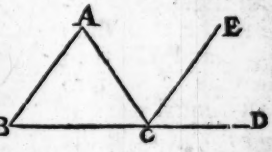
LEt the angle given be X A D, and it is required to make another angle equal to the same. Open the Compasses to any convenient distance, and setting one foot in A, the given angle, with the other describe the arch B C, then with the same extention, set one foot in E, and with the other describe the arch H G, which done, take the extent of the arch-line B C, and setting one foot of the Compasses in G, with the other mark the point H. Lastly, with your Ruler, draw the line E H, which shall include the angle H E G equal to the angle B A C.



PROBL. VII.

The three angles of a right lined Triangle are equal to two right angles.

LEt the Triangle given be A B C, whose side B C being prolonged to D, I say, that the exterior angle A C D, is equal to the two interior or opposite angles A and B joyned together, and that



the

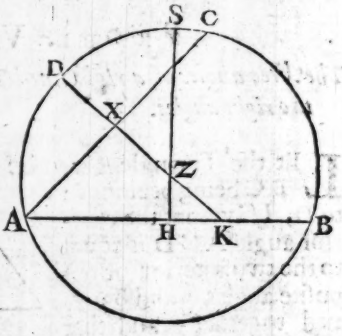
the three angles of the Triangle A B C joyned together, are equal to two right angles.

From the point C draw the line C E parallel to B A according to the 1. *Probl.* and the angle E C A shall be equal to the angle A, becauſe they are coalternate by the 29. 1. *Euclid*, and the exterior angle E C D is equal to the interior angle B, wherefore the whole exterior angle A C D is equal to the two interior angles A and B. And becauſe the two angles ACB and A C D are equal to two right angles, according to the 13. of the 1. of *Euclid*, therefore the three angles A, B and C, are equal to two right angles, which was to be proved.

PROBL. VIII.

Three points being given, which are not in a ſtraight line, to finde out the Center, which will bring them all three into a Circumference.

SUppoſe the three points given be A B and C, and it is required to find the center of a circle, whoſe circumference ſhall paſs thorow them all. Of the three points given make an angle, by drawing the two lines A C and A B, then divide A B into two equal parts at H, and raiſe the



per-

perpendicular S H. In like manner divide the line A C into two equal parts at X, crossing it at right angles by the second *Probl.* then because the line S H is intersected of the line D X K in Z, there is the center, where set one foot of your Compasses, and open the other to the distance A, and so make a circle, which shall pass directly through all the three given points A B and and C, as was required.

PROBL. IX.

To make an equiangled Triangle, whose sides may be equal to a line given.

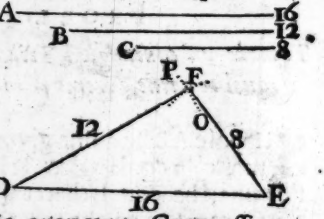
SUppose A B be a line given, and it is required to make an equiangled Triangle, each of whose sides shall be equal thereto. Open the Compasses to the length of the line given, and lay down the same in that place, where you would have the Triangle described, namely in D E, afterward set one foot of your Compasses in the point D, and with the same extent, make the arch X Y, then set one foot of the Compasses in the other end of the line at E, and cross the former arch in C, then laying a Ruler from C to D and E, you shall describe the equiangled equilateral Triangle C D E, as was required.

PROBL.

PROBL. X.

Three lines of unequal lengths being given to make a Triangle, so that the sum of the two shortest be longer then the third line.

SUppose the three lines given be A, B and C, whereof a Triangle is to be made. First, place the longest line A from D to E for the Base of the Triangle, then open the Compasses to the length of the second line B, and set one foot in the end of the Base at D, & make the arch P O, that done, open your Compasses to the third line C, and set one foot in the other end of the Base at E, with the other cross the former arch at F, from which intersection draw the lines F D and F E, which shall include the Triangle F D E, whose sides are equal to the three lines given A B and C.

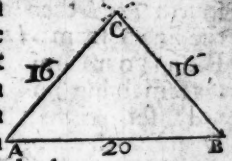


PROBL. XI.

To make an Isosceles Triangle upon a right line given.

LEt the right line given be A B 20. whereon it is required to describe an Isosceles Triangle, whose sides shall be 16, a piece. Open the Compasses

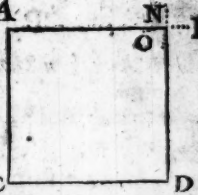
paſſes upon the ſcal to 16, and with one foot in *A*, with the other deſcribe an arch towards C, and at the ſame diſtance, placing one foot in B, croſs the former arch in C, then from that interſection draw lines to *A* and *B*, which ſhall include the Triangle required.



PROBL. XII.

Having a right line given, to make a Geometrical ſquare, whoſe ſide ſhall be equal thereto.

SUppoſe the line given be C D, and it is required to make a ſquare, whoſe ſides ſhall be equal to the ſaid line C D. Firſt, let the angle *D C A* be drawn according to the 4. *Probl.* then ſet the line C D from C to A: next, let one foot of the Compaſſes in D, and with the other make the arch O D, then remove the foot of the Compaſſes into *A*, and croſs that arch at N, from which point draw the lines *A N* and N D, which ſhall include the ſquare *A C D N*.

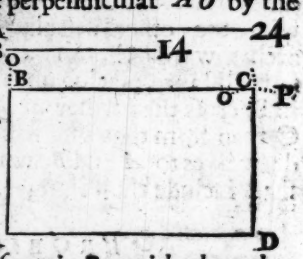


PROBL. XIII.

To make a long ſquare or Oblong, the length and breadth being given.

SUppoſe the line *A* be the length, and R the breadth given. Firſt, upon the line *A D* at the

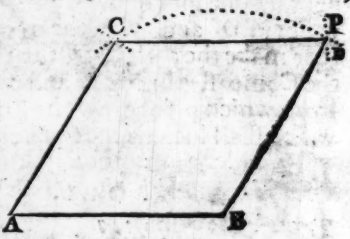
end thereof *A* erect the perpendicular *A O* by the fourth *Probl.* then ſet the line B from *A* to B, and your Compaſſes remaining unſtirred, ſet one foot in D, and with the other make the arch O P. Next open the Compaſſes to the diſtance *A D*, and ſetting one foot in B, with the other croſs the former arch in C, from which interſection draw the lines C B and C D, which ſhall include the long ſquare *A B C D*, as was required.



PROBL. XIV.

To make a Rhombus, the ſide being given.

LEt the line given be *A B*, and at the diſtance *A B* with one foot in B, deſcribe the arch C D, then at the ſame diſtance, ſetting one foot in *A*, croſs the arch-line in C, in which point place one foot of your Compaſſes, and at the former diſtance, croſs the arch line in E. Laſtly, draw the lines *A C*, C E, and E B, which ſhall include the Rhombus *ACEB*, as was required.



PROBL.

PROBL. XV.

Two lines being limited, to make a Rhomboides.

SUppose the line given be *A B* for the length of the Rhomboides, and C D for the breadth. First, at the distance of the given breadth CD, and from one of the ends of the given length, as B, make choice of a point as at Z, and at the same distance of your Compasses setting one foot in *A*, with the other strike an arch towards H, then at the distance of the given length, with one foot in Z, cross the former arch in H, and lastly, draw the lines *H A*, H Z, and Z B, so shall you include the Rhomboides *A H Z B*.

PROBL. XVI.

To finde out the Chord lines in a Circle not exceeding the tenth.

LEt *A B C D* be the Circle given, out of which it is required to finde the Chord lines. First, draw the Diameter *A B*; and the Circle is thereby divided into two equal parts, then opening your Compasses to the Semidiameter, set one foot in *A*, and with the other arch through the circumference at C and D, and so draw the line C D, which shall divide the circumference into three equal parts.

4. This done, draw the line E F, which divideth the Diameter *A B* into two equal parts at right angles, and then draw the line *A E*, which shall be the fourth chord line, or the side of an inscribed square

5. Then to finde the fifth, set one foot of your Compasses in H, and extend the other to E, and with that distance, cross the Diameter in I, and draw the line E I, which shall be the fifth Chord, or the side of a Pentagon.

6. The sixth is the Semidiameter, which is the side of a Sexagon.

7. The seventh is half the third, as C H, or H D, which is the side of an inscribed Septagon.

8. To finde the eight, lay your Ruler upon the center X, and the intersection K, which will cut the Peripherie in L, then draw the line A L, which is the side of an inscribed Octagon.

9. The ninth is a third part of the arch *C A D*, as M D.

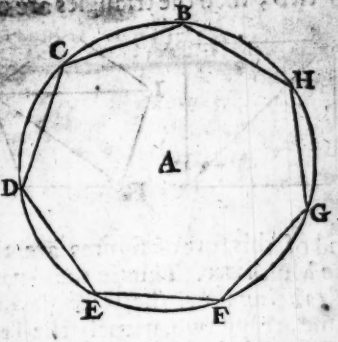
10. The tenth is the line X I, which is the side of an inscribed Decagon.

PROBL.

PROBL. XVII.

To describe any regular Poligon.

FIrst, consider whether it be a Pentagon, Hexagon, Septagon, Octagon, or the like. Then describe a circle, and fitte out the chord, as before, according to the number of the sides of that Poligon, which distance set so many times in the Peripherie of the circle, and then draw lines from point to point, which shall include the Poligon. But for illustration hereof, I shall adde one example of making a Septagon.

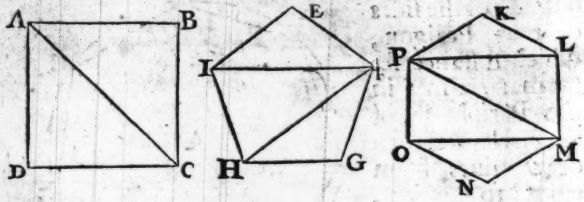


Let *A* be a circle given, wherein a Septagon is to be inscribed, therefore by the last *Probl.* finde out the seventh chord C H, which I place seven times in the circumference, beginning at B, then from point to point draw right lines, within the given circle, which will include the Septagon B C D E F G H, as was required.

PROBL. XVIII.

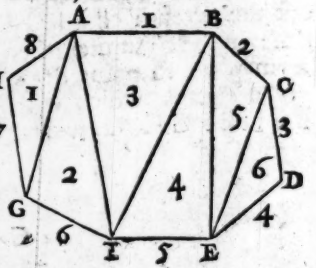
The sides of a Triangulate are more by two then the Triangles whereof it is made.

A Triangulate is a rectilineal figure made & compounded of Triangles, whose sides are more by two, then the triangles are of which it is made,



and of this sort of figures are the Quadrilater and the Multilater. Thus in the Quadrilater ABCD, the sides being four, the Triangles described within the same are but two, namely the Triangles ABC, and ACD. But in the Pentagon EFGHI (the sides being five) it is made and compounded of three Triangles, to wit, EFI, IFH, and FGH.

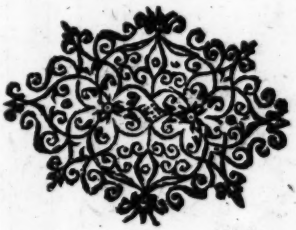
In like manner, the sides of the Hexagon, KL, LM, MN, NO, OP, PK being six, the Triangles are four and so in all multilateral figures, the number of the Triangles, whereof any figure is compounded are ever



less

leſs by two, then the ſides of the figure it ſelf, which more evidently may appear by this multilater A B C D E F G H, where the ſides are eight, and the number of the Triangles ſix, which was to be proved.

The end of the Firſt Book.



UMI

The ART of SURVEYING.

The second Book.

Containing the dimension of all Right lined Triangles.

BEcause the Triangle (in respect of its admirable use in Mathematicks) may justly challenge the superiority of all Geometrical figures, by the help whereof there is not any Question, or Probleme Geometrical, or Astronomical, but may thereby most exactly be resolved; it cannot therefore be unseasonable in this place, to insert all the Problems and Cases incident to Right-lined Triangles, and the rather because the most of them are of extraordinary and common use for a Surveyor, in the taking of Heights and Distan-

Distances, and in finding the Superficial content or area of any Geometrical figure, and more especially in the dimension of all regular Poligons, where their exact superficial capacities cannot otherwise be well obtained, as we shall have occasion afterwards to shew. And albeit I here intend not to speak of Sphærical Triangles, as a thing without the perimeter of an ordinary Surveyors use and practice, yet I shall annex some Problems Astronomical, thereby performed, which will be necessary for him to understand; and for such as would be more fully satisfied in the Doctrine of Trigonometry, relating both to right lined Triangles and Sphærical, I shall refer him to my *Astronomia Britannica*, but to my purpose.

SECT. I.

Of the Dimension of plain Rectangled Triangles.

PROBL. I.

The angles and one Leg being given, to finde the other Leg.

IN the Rectangled Triangle ABC, the side CA is inquired from

The given { Leg *AB* 1123.7943
{ Ang. ABC *gr.* 28.19'49"

Terms of Proportion.

R : t. B :: BA : CA.

Illustra-

Illustration by Numbers.

As the Radius 90. degr.	10,00000
To the tang. of the ang. ABC. 28. 19. '48."	9,73168
So the Leg BA 1123. 7943	3,05069
To the Leg CA 605. 8601	2,78237

PROBL. II.

The Hypotenuse and angles being given, to finde either Leg.

IN the Rectangled Triangle BAC, the side AB is inquired from

The given { Hypotenuse BC. 1276. 7067
Angle A C B gr. 61. 40'. 12".

Terms of Proportion.

R: s. A C B :: B C : *B A.*

Illustration by Numbers.

Radius 90. deg.	10,00000
Sine of the angle *ACB* gr. 61. 40'. 12".	9,94459
Hypotenuse *BC* 1276. 7067	3,10609
Leg *AB* 1123. 7943	3,05068

PROBL. III.

The angles and one Leg being given, to finde the Hypotenuse.

IN the Rectangled Triangle *A B C*, the Hypotenuse *B C* is inquired from

The

The given { Leg BA 1123,7943
Angle BCA gr. 61. 40'. 12''.

Terms of Proposition.

s. ACB : R :: BA : BC.

Illustration by Numbers.

As the Sine of the Angle ACB gr. 61. 40'. 12''.	9,94459
To the Radius 90. degrees	10,00000
So the given Leg AB 1123,7943.	3,05068
To the Hypotenuse BC 1276. 7067	3,10609

PROBL. IV.

The two Legs being given, to finde either Angle.

IN the Rectangled Triangle ABC, the angle ABC is inquired from the

Legs given { BA 1123,7943
CA 605,8601

Terms of Proportion.

BA : CA :: R : t. ABC.

Illustration by Numbers.

As the Leg *BA* 1123. 7943	3,05068
To the Leg *CA* 605. 8601	2,78237
So the Radius 90. degrees	10,00000
To the tangent of the angle *ABC* gr. 28. 19'. 48''	9,73169

PROBL.

Probl. V.

The Hypotenuse and a Leg being given, to finde either angle.

IN the Rectangled Triangle BAC, the angle ACB is inquired from

The given { Leg AB 1123. 7943
Hypotenuse BC 1276. 7067

Terms of Proportion.

$BC : BA :: R : s.ACB.$

Illustration by Numbers.

As the Hypotenuse BC 1276. 7067	3,10609
To the Leg BA 1123. 7943	3,05068
So the Radius 90. degrees	10,00000
To the Sine of the angle ACB gr. 61. 40'. 12''.	9,94459

Probl. VI.

The Legs being given, to finde the Hypotenuse.

IN the Rectangled Triangle ABC, the Hypothenuse BC is required from the

Given Legs { AB 1123. 7943
AC 605. 8601

The Termes of Proportion.

1. $BA : CA :: R : t.ABC.$
2. $s.ABC : R :: CA : BC.$

Illustra-

Illustration by Numbers.

1. For the angle *A B C.*

As the Leg *A B* 1123. 7943	3,05068
To the Leg *A C* 605. 8601	2,78237
So the Radius 90. degrees	10,00000
To the tangent of the angle *A B C* gr. 28. 19'. 48".	9,73169

2. For the Hypotenuse *B C.*

As the Sine of the ang. *ABC* gr. 28. 19'. 48".	9,67628
To the Radius 90. deg.	10,00000
So the Leg *A C* 605. 8601	2,78237
To the Hypotenuse *B C* 1276. 7067.	3,10609

PROBL. VII.

The Hypotenuse and a Leg being given, to finde the other Leg.

IN the Rectangled Triangle A B C, the Leg A C is inquired from

The given { Hypotenuse B C 1276. 7067
Leg A B 1123. 7943.

Terms of Proportion.

1. B C : B A : : R : s. A C B.
2. R : s. A B C : : B C : A C.

Or it may be performed with more ease by one operation

Log. B A + B C *plus*; Log. B A — BC, Divis. *per* 2 = Log. *C A.*

Illustra-

Illustration by Numbers.

Hypot. BC 1276,7067	Sum. 2400.5010,		3,38030
Leg. BA 1123,7943	Differ. 152,9124.		2,18444
		Aggregate	5,56474
Leg. AC 605.8601		Semiaggreg.	2,78237

SECT. II.

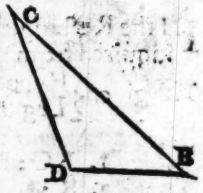
Of the Dimension of Plain Obliquangled Triangles.

PROBL. I.

Two sides and an angle opposite to one of them being given, to finde the angle oppesite to the other side.

IN the Obliquangled Triangle BCD the angle B is inquired from

The given sides { BC 1276.7067 / CD 865.1765



Terms of Proportion.

BC: s. BDC :: CD: s. CBD

Illustration by Numbers.

As the side BC 1276,7067	3,10609
To the sine of the angle BDC 116d.12'.22''	9,95289
So the side CD 865.1765	2,93710
	12,88999
To the sine of the angle CBD 37d.26'.43''.	9,78390

PRO I.

PROBL. II.

Two sides with the angle included by them being given, to finde either of the other angles.

IN the Obliquangled Triangle BCD, either angle at C or D is inquired, from the given

Sides { BC 1276,7067
BD 631.5525

Angle DBC 37 *d.* 26′. 45″.

Terms of Proportion.

$$BD+CD : BD-CD :: t.\frac{G+B}{2} : t.\frac{X}{2}$$

Then $\frac{C+B}{2} \pm \frac{}{} = \text{Ang: } \begin{matrix} DCB \\ DBC \end{matrix}$

Illustration by Numbers.

As the summe of the sides BC and BD 1908,2592	3,28063
To their difference 645,1542	2,80966
So the tangent of half the summe of the opposite angles 71*d.* 16′. 38″.	10,46989
	13,27956
To the tangent of half the difference 44*d*,55′. 44″.	9,99892
To the half sum of the angles	71 *d.* 16′. 38″
Add the half difference	44. 55. 44.
It giveth the angle BDC 116.	12. 22.
Substract:	71 *d.* 16′. 38″.
	44. 55. 44.
The angle BCD.	26. 20. 54.

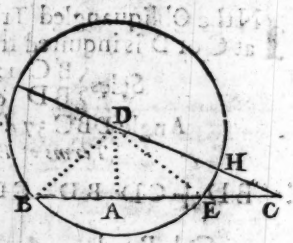
PROBL.

PROBL. III.

The three sides being given, to finde an angle.

IN the Obliquangled Triangle BCD, either angle is inquired. Suppose the angle DBC from

The given sides	CB	1276,7067
	BD	631,5525
	CD	865,1765



Terms of Proportion.

1. BC : CD + BD :: CD — BD : CE
2. BD : R :: BA : cos. B.

Illustration in Numbers.

1.

As the greater side BC 1276,7067	3,10609
To the sum of CD and DB 1496,7290	3,17514
So the difference HC 233,6240	2,36851
	5,54366
To the difference of the Segm. of the Base CE 273,8858	2,43757
The difference of this and the Base BE	1001,8209
Whose half BA = EA	501,4104
Hence CA shall be	775,2962

2.

As the Hypotenuse BD 631,5525	2,80041
To the Leg BA 501,4104	2,70019
So the Radius 90 degrees	10,00000
To the Sine of the angle BDA 52 d. 33′,16″	9,89978

Whose

Whose complement ABD is 37*d*. 26′. 44″. The like courseare you to take for the angle A C D.

This Probleme may more readily be resolved, and that at one Operation by the following Precept, the ground whereof is drawn from the learned Mr. *Brigges*, his *Arithmetica Logarithmica*, *Cap.* 10.

De dimidio collectorum laterum, latera sigillatim subducantur, &c. From half the sum of the sides substract the sides one after another, and let the sum of the Logarithmes of the half sum of the sides and difference of the sides subtending the Angle sought for, be substracted from the sum of the Logarithmes of the other differences and the double Radius; the half of the remainder shall be the Logarithmes of the Tangent of half the inquired angle.

Let the angle subtended by the greater side be inquired, *viz.* B D C.

Illustration by Numbers.

The side	BC	1276,7067	
	DC	865,1765	
	DB	631,5525	
The summe of the sides		2773,4357	
The half sum		1386,7178	3,14199
The differ. of CB		110,0111	2,04143
		The sum	5,18342 A

The

The differ. of the side CD 521,5413	2,71729
The differ. of the side BD 755,1653	2,87804
The double Radius	20,00000
The sum	25,59533 B
The sum	5,18342 A
The difference	20,41191
The half differ.	10,20595 is

the Tangent of 58*d*. 6′. 11″. the double whereof 116. deg. 12′. 23″. is the Angle inquired BDC.

PROBL. IV.

The Angles and a side being given, to finde either of the other sides.

IN the Obliquangled Triangle BCD, the side DC is inquired from the given

Angles { D B C 37*d*. 26. 43 ½
D C B 26 20 53 ½
B D C 116. 12. 23

Side B C 1276, 7067.

Terms of Proportion.

s. D : B C :: s. B : D C.

Illustration by Numbers.

As the sine of the angle BDC 63*d*. 47′. 37″.	9,95289
To the side BC 1276,7067	3,10609
So the sine of the angle DBC 37*d*. 26′. 43″. ½	9,78391
	12,89000
To the side D C 865,1765	2,93711.

PROBL.

PROBL. V.

Two sides with the angle included by them being given, to finde the third side.

IN the Obliquangled Triangle *B C D*, the side *BC* is inquired from

The given sides { *D C* 865,1765 / *B D* 631,5525

And the Angle *B D C* 116*d*. 12'. 23".

First let the other angles be inquired by the second Probleme of this Sect. and the angles being found, the side inquired may be had by the last Probleme; Examples are needless.

The end of the second Book.

Advertisement.

WHereas the *following Tables of Sines and Tangents do extend only to every tenth Minute of the Quadrant, and also the Table of Logarithms onely to One Thousand, I thought good to give notice to the Reader, that there hath been lately printed a most excellent and useful Book for all Students in the Mathematicks, Intituled,* TRIGONOMETRIA BRITANNICA, *which contains the making of the Tables of Sines, Tangents, and Logarithms, and also there use in resolving of all Triangles either Plain or Spherical, in which Book you have the Sines and Tangents to every degree and hundred part of a degree of the Quadrant, and the Logarithms of all Numbers, from One to an hundred Thousand.*

Canon Triangulorum:

OR, A

TABLE

OF

Artificial Sines and Tangents

To a Radius of 1000000. Parts, and every 10. Min. of the Quadrant.

Together

With a TABLE of Logarithms to 1000. being of singular use in the Solution

OF

TRIANGLES.

Cuncta Trigonus habet satagit quæ docta Mathesis:
Ille aperit clausam quicquid Olympus habet.

A Table of Artificial Sines and Tangents.

m.Gr.	Sin.	Cosin.	Tang.	Cotang.	m.Gr.
0 0	0,	10,00000	0,00000	Infinita.	0 90
10	7,46372	9,99999	7,46373	12,53627	50
20	7,76475	9,99999	7,76476	12,24524	40
30	7,94084	9,99998	7,94086	12,05914	30
40	8,06577	9,99997	8,06581	11,93419	20
50	8,16268	9,99995	8,16274	11,83726	10
1 0	8,24185	9,99993	8,24192	11,75808	0 89
10	8,30879	9,99991	8,30888	11,69112	50
20	8,36678	9,99988	8,36690	11,63310	40
30	8,41792	9,99985	8,41807	11,58193	30
40	8,46366	9,99981	8,46385	11,53615	20
50	8,50504	9,99978	8,50527	11,49473	10
2 0	8,54282	9,99973	8,54308	11,45692	0 88
10	8,57756	9,99969	8,57788	11,42212	50
20	8,60973	9,99964	8,61010	11,38990	40
30	8,63968	9,99958	8,64009	11,35991	30
40	8,66769	9,99953	8,66816	11,33184	20
50	8,69400	9,99947	8,69453	11,30547	10
3 0	8,71880	9,99940	8,71940	11,28060	0 87
10	8,74226	9,99933	8,74292	11,25708	50
20	8,76451	9,99926	8,76525	11,23475	40
30	8,78567	9,99919	8,78649	11,21351	30
40	8,80585	9,99911	8,80674	11,19326	20
50	8,82513	9,99903	8,82610	11,17390	10
4 0	8,84358	9,99894	8,84464	11,15536	0 86
10	8,86128	9,99885	8,86243	11,13757	50
20	8,87828	9,99876	8,87953	11,12047	40
30	8,89464	9,99866	8,89508	11,10402	30
40	8,91040	9,99856	8,91185	11,08815	20
50	8,92561	9,99845	8,92716	11,07284	10
5 0	8,94029	9,99834	8,94195	11,05805	0 85
10	8,95450	9,99823	8,95627	11,04373	50
20	8,96825	9,99810	8,97013	11,02987	40
30	8,98157	9,99800	8,98358	11,01642	30
40	8,99450	9,99787	8,99662	11,00338	20
50	9,00704	9,99773	9,00930	10,99070	10.
Gr. m.	Cosin.	Sin.	Cotang.	Tang.	m.Gr

A Table of Artificial Sines and Tangents.

Gr.m.	Sin.	Cosin.	Tang.	Cotang.	
6 0	9,01923	9,99761	9,02162	10,97838	0 84
10	9,03109	9,99748	9,03361	10,96639	50
20	9,04262	9,99734	9,04528	10,95472	40
30	9,05386	9,99720	9,05666	10,94334	30
40	9,06480	9,99705	9,06775	10,93225	20
50	9,07548	9,99690	9,07858	10,92142	10
7 0	9,08589	9,99675	9,08914	10,91086	0 83
10	9,09606	9,99659	9,09947	10,90053	50
20	9,10599	9,99643	9,10956	10,86044	40
30	9,11570	9,99627	9,11943	10,88057	30
40	9,12519	9,99610	9,12909	10,87091	20
50	9,13447	9,99593	9,13854	10,86146	10
8 0	9,14355	9,99575	9,14780	10,85220	0 82
10	9,15245	9,99557	9,15688	10,84312	50
20	9,16116	9,99539	9,16577	10,83423	40
30	9,16970	9,99520	9,17450	10,82550	30
40	9,17807	9,99501	9,18306	10,81694	20
50	9,18628	9,99482	9,19146	10,80854	10
9 0	9,19433	9,99462	9,19971	10,80029	0 81
10	9,20223	9,99442	9,20782	10,79218	50
20	9,20999	9,99421	9,21578	10,78422	40
30	9,21761	9,99400	9,22361	10,77639	30
40	9,22509	9,99379	9,23130	10,76870	20
50	9,23244	9,99357	9,23887	10,76113	10
10 0	9,23967	9,99335	9,24632	10,75368	0 80
10	9,24679	9,99313	9,25365	10,74635	50
20	9,25376	9,99290	9,26086	10,73914	40
30	9,26063	9,99266	9,26797	10,73203	30
40	9,26739	9,99243	9,27496	10,72504	20
50	9,27405	9,99219	9,28186	10,71814	10
11 0	9,28060	9,99195	9,28865	10,71135	0 79
10	9,28705	9,99170	9,29535	10,70465	50
20	9,29340	9,99145	9,30195	10,69805	40
30	9,29965	9,99119	9,30846	10,69154	30
40	9,30582	9,99293	9,31488	10,68512	20
50	9,31190	9,99068	9,32122	10,67878	10.78
Gr.m.	Cosin.	Sin.	Cotang.	Tang.	m.Gr.

A Table of Artificial Sines and Tangents.

Gr.m.	Sin.	Cosin.	Tang.	Cotang.	m.Gr.
12 0	9,31788	9,99040	9,32747	10,67253	0 78
10	9,32378	9,99013	9,33365	10,66635	50
20	9,32960	9,98986	9,33974	10,66026	40
30	9,33534	9,98958	9,34575	10,65424	30
40	9,34099	9,98930	9,35170	10,64830	20
50	9,34658	9,98901	9,35757	10,64243	10
13 0	9,35209	9,98872	9,36336	10,63664	0 77
10	9,35752	9,98843	9,36909	10,63091	50
20	9,36280	9,98813	9,37476	10,62524	40
30	9,36818	9,98783	9,38035	10,61965	30
40	9,37341	9,98752	9,38589	10,61411	20
50	9,37858	9,98722	9,39136	10,60864	10
14 0	9,38367	9,98690	9,39677	10,60323	0 76
10	9,38871	9,98659	9,40212	10,59788	50
20	9,39368	9,98627	9,40742	10,59258	40
30	9,39860	9,98594	9,41266	10,58734	30
40	9,40345	9,98561	9,41784	10,58216	20
50	9,40825	9,98528	9,42297	10,57703	10
15 0	9,41299	9,98494	9,42805	10,57195	0 75
10	9,41768	9,98460	9,43308	10,56692	50
20	9,42232	9,98426	9,43046	10,56194	40
30	9,42690	9,98391	9,44299	10,55701	30
40	9,43143	9,98356	9,44787	10,55213	20
50	9,43592	9,98320	9,45271	10,54729	10
16 0	9,44034	9,98284	9,45750	10,54250	0 74
10	9,44472	9,98248	9,46224	10,53776	50
20	9,44905	9,98211	9,46694	10,53305	40
30	9,45334	9,98174	9,47160	10,52839	30
40	9,45758	9,98136	9,47622	10,52378	20
50	9,46178	9,98098	9,48080	10,51920	10
17 0	9,46593	9,98060	9,48534	10,51466	0 73
10	9,47004	9,98021	9,48984	10,51016	50
20	9,47411	9,97982	9,49430	10,50570	40
30	9,47814	9,97942	9,49872	10,50128	30
40	9,48213	9,97902	9,50311	10,49689	20
50	9,48607	9,97861	9,50746	10,49254	10.72
Gr.m.	Cosin.	Sin.	Cotang.	Tang.	m.Gr.

A Table of Artificial Sines and Tangents.

Gr.m.	Sin.	Cosin.	Tang.	Cotang.	m. Gr.
18 0	9,49998	9,97821	9,51178	10,48822	0 72
10	9,49385	9,97779	9,51606	10,48394	50
20	9,49768	9,97738	9,52030	10,47969	40
30	9,50147	9,97796	9,52452	10,47548	30
40	9,50523	9,97653	9,52870	10,47130	20
50	9,50895	9,97610	9,53285	10,46715	10
19 0	9,51264	9,97567	9,53697	10,46303	0 71
10	9,51629	9,97528	9,54106	10,45894	50
20	9,51991	9,97479	9,54512	10,45488	40
30	9,52349	9,97434	9,54915	10,45085	30
40	9,52704	9,97390	9,55315	10,44685	20
50	9,53056	9,97344	9,55712	10,44288	10
20 0	9,53405	9,97299	9,56107	10,43893	0 70
10	9,53751	9,97252	9,56498	10,43502	50
20	9,54093	9,97286	9,56887	10,43113	40
30	9,54432	9,97159	9,57274	10,42726	30
40	9,54769	9,97111	9,57658	10,42342	20
50	9,55102	9,97063	9,58039	10,41961	10
21 0	9,55433	9,97015	9,58418	10,41582	0 69
10	9,55761	9,96966	9,58794	10,41206	50
20	9,56085	9,96917	9,59168	10,40832	40
30	9,56407	9,96868	9,59540	10,40460	30
40	9,56727	9,96818	9,59909	10,40091	20
50	9,57043	9,96767	9,60276	10,39724	10
22 0	9,57357	9,96716	9,60641	10,39359	0 68
10	9,57669	9,96665	9,61004	10,38996	50
20	9,57978	9,96613	9,61364	10,38636	40
30	9,58284	9,96561	9,61722	10,38278	30
40	9,58588	9,96509	9,62079	10,37921	20
50	9,58889	9,96456	9,62433	10,37567	10
23 0	9,59188	9,96402	9,62785	10,37215	0 67
10	9,59484	9,96349	9,63135	10,36865	50
20	9,59778	9,96294	9,63484	10,36516	40
30	9,60070	9,96240	9,63830	10,36170	30
40	9,60359	9,96184	9,64175	10,35825	20
50	9,60646	9,96129	9,64517	10,35483	10.66
Gr.m.	Cosin.	Sin.	Cotang.	Tang.	

A Table of Artificial Sines and Tangents.

Gr. m.	Sin.	Cosin.	Tang.	Corang.	
24 0	9,60991	9,96073	9,64858	10,35142	0 66
10	9,61215	9,96017	9,65197	10,34803	50
20	9,61494	9,95960	9,65535	10,34465	40
30	9,61773	9,95902	9,65870	10,34130	30
40	9,62049	9,95844	9,66204	10,33796	20
50	9,62323	9,95786	9,66537	10,33463	10
25 0	9,62595	9,95728	9,66867	10,33133	0 65
10	9,62865	9,95668	9,67196	10,32804	50
20	9,63133	9,95609	9,67524	10,32476	40
30	9,63398	9,95549	9,67859	10,32150	30
40	9,63662	9,95488	9,68174	10,31826	20
50	9,63924	9,95427	9,68497	10,31503	10
26 0	9,64184	9,95366	9,68818	10,31182	0 64
10	9,64442	9,95304	9,69138	10,30862	50
20	9,64698	9,95242	9,69457	10,30543	40
30	9,64953	9,95179	9,69774	10,30226	30
40	9,65205	9,95116	9,70089	10,29911	20
50	9,65456	9,95052	9,70404	10,29596	10
27 0	9,65705	9,94988	9,70717	10,29283	0 63
10	9,65952	9,94923	9,71028	10,28972	50
20	9,66197	9,94858	9,71339	10,28671	40
30	9,66441	9,94793	9,71648	10,28352	30
40	9,66682	9,94727	9,71956	10,28944	20
50	9,66922	9,94660	9,72262	10,27738	10
28 0	9,67161	9,94593	9,72567	10,27433	0 62
10	9,67393	9,94526	9,72872	10,27128	50
20	9,67633	9,94458	9,73175	10,26825	40
30	9,67866	9,94360	9,73476	10,26524	30
40	9,68098	9,94321	9,73777	10,26223	20
50	9,68328	9,94252	9,74077	10,25623	10
29 0	9,68557	9,94182	9,74375	10,25625	0 61
10	9,68784	9,94112	9,74673	10,25327	50
20	9,69010	9,94041	9,74969	10,25031	40
30	9,69234	9,93970	9,75264	10,24736	30
40	9,69456	9,93898	9,75558	10,24442	20
50	9,66677	9,93826	9,75852	10.24448	1060
Gr. m.	Cosin.	Sin.			Gr. m

A Table of Artificial Sines and Tangents.

Gr m.	Sin.	Cosin.	Tang.	Cotang.	Gr.m
30 0	9,69897	9,93753	9,76144	10,23856	0 60
10	9,70115	9,93680	9,76435	10,23565	50
20	9,70332	9,93606	9,76726	10,23278	40
30	9,70547	9,93532	9,77015	10,22985	30
40	9,70760	9,93457	9,77303	10,22697	20
50	9,70973	9,93382	9,77591	10,22409	10
31 0	9,71184	9,93307	9,77877	10,22123	0 59
10	9,71393	9,93230	9,78163	10,21837	50
20	9,71601	9,93154	9,78448	10,21552	40
30	9,71808	9,93077	9,78732	10,21268	30
40	9,72014	9,92999	9,79015	10,20985	20
50	9,72218	9,92921	9,79297	10,20703	10
32 0	9,72421	9,92842	9,79579	10,20421	0 58
10	9,72622	9,92763	9,79860	10,20140	50
20	9,72823	9,92683	9,80140	10,19860	40
30	9,73022	9,92603	9,80419	10,19581	30
40	9,73219	9,92522	9,80697	10,19303	20
50	9,73417	9,92441	9,80975	10,19025	10
33 0	9,73611	9,92359	9,81252	10,18748	0 57
10	9,73805	9,92277	9,81528	10,18412	55
20	9,73997	9,92194	9,81803	10,18196	40
30	9,74189	9,92111	9,82078	10,17922	30
40	9,74379	9,92027	9,82352	10,17648	20
50	9,74568	9,91942	9,82626	10,17374	10
34 0	9,74756	9,91857	9,82899	10,17104	0 56
10	9,74943	9,91772	9,83171	10,16829	50
20	9,75128	9,91686	9,83442	10,16558	40
30	9,75313	9,91599	9,83713	10,16287	30
40	9,75496	9,91512	9,83984	10,16016	20
50	9,75678	9,91425	9,84253	10,15747	10
35 0	9,75859	9,91336	9,84523	10,15477	0 55
10	9,76039	9,91248	9,84791	10,15209	50
20	9,76218	9,91158	9,85059	10,14941	40
30	9,76395	9,91069	9,85327	10,14673	30
4	9,76572	9,90978	9,85594	10,14406	20
50	9,76747	9,90887	9,85860	10,14140	1058
Gr. m.	Cosin.	Sin.	Cotang.	Tang.	

A Table of Artificial Sines and Tangents.

Gr.m.	Sin.	Cosin.	Tang.	Cotang.	m.Gr.
36 0	9,76922	9,90796	9,86126	10,13874	0 54
10	9,77095	9,90704	9,86391	10,13609	50
20	9,77267	9,90611	9,86656	10,13344	40
30	9,77439	9,90518	9,86921	10,13079	30
40	9,77609	9,90424	9,87185	10,12815	20
50	9,77778	9,90330	9,87448	10,12552	10
37 0	9,77946	9,90235	9,87711	10,12289	0 53
10	9,78113	9,90139	9,87974	10,12026	50
20	9,78280	9,90043	9,88236	10,11764	40
30	9,78445	9,89947	9,88498	10,11502	30
40	9,78609	9,89849	9,88759	10,11241	20
50	9,78772	9,89752	9,89020	10,10980	10
38 0	9,78934	9,89653	9,89281	10,10719	0 52
10	9,79095	9,89554	9,89541	10,10459	50
20	9,79256	9,89455	9,89800	10,10199	40
30	9,79415	9,89354	9,90060	10,09939	30
40	9,79573	9,89254	9,90320	10,09680	20
50	9,79731	9,89152	9,90578	10,09422	10
39 0	9,79887	9,89050	9,90837	10,09163	0 51
10	9,80043	9,88948	9,91095	10,08905	50
20	9,80197	9,88844	9,91353	10,08647	40
30	9,80351	9,88741	9,91610	10,08390	30
40	9,80504	9,88636	9,91868	10,08132	20
50	9,80656	9,88531	9,92125	10,07875	10
40 0	9,80807	9,88425	9,92381	10,07619	0 50
10	9,80957	9,88319	9,92638	10,07362	50
20	9,81006	9,88212	9,92894	10,07106	40
30	9,81254	9,88104	9,93150	10,06850	30
40	9,81402	9,87996	9,93406	10,06594	20
50	9,81548	9,87887	9,93661	10,06339	10
41 0	9,81694	9,87778	9,93916	10,06084	0 49
10	9,81839	9,87668	9,94171	10,05829	50
20	9,81983	9,87557	9,94426	10,05574	40
30	9,82126	9,87446	9,94681	10,05319	30
40	9,82269	9,87333	9,94935	10,05065	20
50	9,82410	9,87221	9,95190	10,04810	10,48
Gr. r.	Cosin.	Sin.	Cotang.	Tang.	m. Gr.

A Table of Artificial Sines and Tangents.

Gr. m.	Sin.	Cosin.	Tang.	Cotang.	m. Gr.
42 0	9,82551	9,87107	9,95444	10,04556	0 48
10	9,82691	9,86993	9,95698	10,04302	50
20	9,82830	9,86878	9,95952	10,04048	40
30	9,82968	9,86763	9,96205	10,03795	30
40	9,83106	9,86647	9,96459	10,03541	20
50	9,83242	9,86530	9,96712	10,03288	10
43 0	9,83378	9,86413	9,96966	10,03034	0 47
10	9,83513	9,86294	9,97219	10,02781	50
20	9,83648	9,86176	9,97472	10,02528	40
30	9,83781	9,86056	9,97725	10,02275	30
40	9,83914	9,85936	9,97978	18,02022	20
50	9,84046	9,85815	9,98231	10,01769	10
44 0	9,84177	9,85693	9,98484	10,01516	0 46
10	9,84308	9,85571	9,98736	10,01264	50
20	9,84437	9,85448	9,98989	10,01011	40
30	9,84566	9,85324	9,99242	10,00758	30
40	9,84694	9,85200	9,99495	10,00505	20
50	9,84822	9,85074	9,99747	10,00253	10
45 0	9,84948	9,84948	10,00000	10,00000	0 45
Gr. m.	Cosin.	Sin.	Cotang.	Tang.	m. Gr.

Explanation of the Table by Example.

1. Suppose it be required to finde the Sine and Tangent of 30. degr. 20. min. therefore I seek the same in the first Columne on the left hand under Gr. 1. and I finde the Sine thereof 9, 70332. and the Tangent 9,76725, its Cosine 9, 93606, and the Cotangent 10, 23274.

2. But suppose 9,73997. be a Sine given, and the Arch thereof is required; therefore I seek in the second Columne amongst the Sines for 9, 73997. and against it, on the left hand, I find 33. degrees 20. min. which is the Arch answering thereunto.

But if you finde not your just number, then take the neerest in the Table; which you shall finde exact enough for Instrumental Obsetvations.

A Table of Logarithmes.

N	Logar:	N	Logar:	N	Logar.	N	Logar.
0	0,00000	34	1,53148	68	1,83251	102	2,00860
1	0,00000	35	1,54407	69	1,83885	103	2,01284
2	0,30103	36	1,55630	70	1,84510	104	2,01703
3	0,47713	37	1,56820	71	1,85126	105	2,02119
4	0,60206	38	1,57978	72	1,85733	106	2,02530
5	0,69897	39	1,59106	73	1,86332	107	2,02938
6	0,77815	40	1,60206	74	1,86923	108	2,03342
7	0,84510	41	1,61278	75	1,87506	109	2,03743
8	0,90309	42	1,62325	76	1,88081	110	2,04139
9	0,95424	43	1,63347	77	1,88649	111	2,04532
10	1,00000	44	1,64345	78	1,89209	112	2,04922
11	1,04139	45	1,65321	79	1,89763	113	2,05308
12	1,07918	46	1,66276	80	1,90309	114	2,05690
13	1,11394	47	1,67210	81	1,90848	115	2,06070
14	1,14613	48	1,68124	82	1,91381	116	2,06446
15	1,17609	49	1,69020	83	1,91908	117	2,06819
16	1,20412	50	1,69897	84	1,92428	118	2,07188
17	1,23045	51	1,70757	85	1,92942	119	2,07555
18	1,25527	52	1,71600	86	1,93450	120	2,07918
19	1,27875	53	1,72427	87	1,93952	121	2,08278
20	1,30103	54	1,73239	88	1,94448	122	2,08636
21	1,32222	55	1,74036	89	1,94939	123	2,08990
22	1,34242	56	1,74819	90	1,95424	124	2,09342
23	1,36173	57	1,75587	91	1,95904	125	2,09691
24	1,38021	58	1,76343	92	1,96379	126	2,10037
25	1,39794	59	1,77085	93	1,96848	127	2,10380
65	1,41497	60	1,77815	94	1,97313	128	2,10721
27	1,43136	61	1,78533	95	1,97772	129	2,11059
28	1,44716	62	1,79219	96	1,98117	130	2,11394
29	1,46240	63	1,79934	97	1,98677	131	2,11727
30	1,47712	64	1,80648	98	1,99123	132	2,12057
31	1,49136	65	1,81291	99	1,99563	133	2,12385
32	1,50515	66	1,81954	100	2,00000	134	2,12710
33	1,51851	67	1,82607	101	2,00432	135	2,13033

A Table of Logarithmes.

N	Logar.	N	Logar.	N	Logar.	N	Logar.
136	2,13354	170	2,23045	204	2,30563	238	2,37658
137	2,13672	171	2,23300	205	2,31175	239	2,37840
138	2,13988	172	2,23553	206	2,31387	240	2,38021
139	2,14301	173	2,23805	207	2,31597	241	2,38202
140	2,14613	174	2,24055	208	2,31806	242	2,38381
141	2,14922	175	2,24304	209	2,32015	243	2,38561
142	2,15229	176	2,24551	210	2,32222	244	2,38739
143	2,15534	177	2,24797	211	2,32428	245	2,38917
144	2,15836	178	2,25042	212	2,32634	246	2,39093
145	2,16137	179	2,25285	213	2,32838	247	2,39270
146	2,16435	180	2,25527	214	2,33041	248	2,39445
147	2,16732	181	2,25768	215	2,33244	249	2,39620
148	2,17026	182	2,26007	216	2,33445	250	2,39794
149	2,17319	183	2,26245	217	2,33646	251	2,39967
150	2,17609	184	2,26482	218	2,33846	252	2,40140
151	2,17898	185	2,26717	219	2,34044	253	2,40312
152	2,18184	186	2,26951	220	2,34243	254	2,40483
153	2,18469	187	2,27184	221	2,34439	255	2,40654
154	2,18752	188	2,27416	222	2,34635	256	2,40824
155	2,19033	189	2,27646	223	2,34830	257	2,40993
156	2,19312	190	2,27875	224	2,35025	258	2,41162
157	2,19590	191	2,28103	225	2,35218	259	2,41330
158	2,19866	192	2,28330	226	2,35411	260	2,41497
159	2,20140	193	2,28556	227	2,35603	261	2,41664
160	2,20412	194	2,28780	228	2,35793	262	2,41830
161	2,20683	195	2,29003	229	2,35983	263	2,41996
162	2,20951	196	2,29226	230	2,36173	264	2,42160
163	2,21219	197	2,29447	231	2,36361	265	2,42325
164	2,21484	198	2,29666	232	2,36549	266	2,42488
165	2,21748	199	2,29885	233	2,36736	267	2,42651
166	2,22011	200	2,30103	234	2,36922	268	2,42813
167	2,22272	201	2,30320	235	2,37107	269	2,42975
168	2,22531	202	2,30535	236	2,37291	270	2,43136
169	2,22789	203	2,30750	237	2,37475	271	2,43297

A Table of Logarithmes.

N	Logar.	N	Logar.	N	Logar.	N	Logar.
272	2,43457	306	2,48572	340	2,53148	374	2,57287
273	2,43616	307	2,48714	341	2,53275	375	2,57403
274	2,43775	308	2,48855	342	2,53403	376	2,57519
275	2,43933	309	2,48996	343	2,53529	377	2,57634
276	2,44091	310	2,49136	344	2,53656	378	2,57749
277	2,44248	311	2,49276	345	2,53782	379	2,57864
278	2,44404	312	2,49415	346	2,53908	380	2,57978
279	2,44560	313	2,49554	347	2,54033	381	2,58092
280	2,44716	314	2,49693	348	2,54158	382	2,58206
281	2,44871	315	2,49831	349	2,54283	383	2,58320
282	2,45025	316	2,49969	350	2,54407	384	2,58433
283	2,45179	317	2,50106	351	2,54531	385	2,58546
284	2,45332	318	2,50243	352	2,54654	386	2,58659
285	2,45484	319	2,50379	353	2,54777	387	2,58771
286	2,45626	320	2,50515	354	2,54900	388	2,58883
287	2,45789	321	2,50650	355	2,55023	389	2,58993
288	2,45939	322	2,50786	356	2,55145	390	2,59106
289	2,46090	323	2,50920	357	2,55267	391	2,59218
290	2,46240	324	2,51054	358	2,55388	392	2,59329
291	2,46389	325	2,51188	359	2,55509	393	2,59439
292	2,46538	326	2,51322	360	2,55630	394	2,59549
293	2,46687	327	2,51455	361	2,55751	395	2,59660
294	2,46835	328	2,51587	362	2,55871	396	2,57769
295	2,46982	329	2,51720	363	2,55991	397	2,59879
296	2,47129	330	2,51851	364	2,56110	398	2,59988
297	2,47276	331	2,51983	365	2,56229	399	2,60097
298	2,47422	332	2,52114	366	2,56348	400	2,60206
299	2,47567	333	2,52244	367	2,56467	401	2,60314
300	2,47712	334	2,52375	368	2,56585	402	2,60423
301	2,47856	335	2,52504	369	2,56703	403	2,60530
302	2,48001	336	2,52634	370	2,56820	404	2,60638
303	2,48144	337	2,52763	371	2,56937	405	2,60745
304	2,48287	338	2,52892	372	2,57054	406	2,60853
305	2,48430	339	2,53020	373	2,57171	407	2,60959

A Table of Logarithmes.

N	Logar:	N	Logar:	N	Logar.	N	Logar.
408	2,61066	442	2,64542	476	2,67761	510	2,70757
409	2,61172	443	2,64640	477	2,67852	511	2,70842
410	2,61278	444	2,64738	478	2,67943	512	2,70927
411	2,61384	445	2,64836	479	2,68033	513	2,71012
412	2,61490	446	2,64933	480	2,68124	514	2,71096
413	2,61595	447	2,65031	481	2,68214	515	2,71181
414	2,61700	448	2,65128	482	2,68305	516	2,71265
415	2,61805	449	2,65225	483	2,68395	517	2,71349
416	2,61909	450	2,65321	484	2,68484	518	2,71433
417	2,62014	451	2,65418	485	2,68574	519	2,71517
418	2,62118	452	2,65514	486	2,68664	520	2,71600
419	2,62221	453	2,65610	487	2,68753	521	2,71684
420	2,62325	454	2,65706	488	2,68842	522	2,71767
421	2,62428	455	2,65801	489	2,68931	523	2,71850
422	2,62531	456	2,65956	490	2,69020	524	2,71933
423	2,62634	457	2,65991	491	2,69108	525	2,72016
424	2,62737	458	2,66086	492	2,69196	526	2,72099
425	2,62839	459	2,66181	493	2,69285	527	2,72181
426	2,62941	460	2,66276	494	2,69373	528	2,72263
427	2,63043	461	2,66370	495	2,69460	529	2,72346
428	2,63144	462	2,66464	496	2,69548	530	2,72428
429	2,63246	463	2,66558	497	2,69636	531	2,72509
430	2,63347	464	2,66652	498	2,69723	532	2,72591
431	2,63448	465	2,66745	499	2,69810	533	2,72673
432	2,63548	466	2,66838	500	2,69897	534	2,72754
433	2,63649	467	2,66932	501	2,69983	535	2,72835
434	2,63749	468	2,67024	502	2,70070	536	2,72916
435	2,63849	469	2,67117	503	2,70157	537	2,72997
436	2,63949	470	2,67210	504	2,70243	538	2,73078
437	2,64048	471	2,67302	505	2,70329	539	2,73159
438	2,64147	472	2,67394	506	2,70415	540	2,73239
439	2,64246	473	2,67486	507	2,70501	541	2,73320
440	2,64345	474	2,67578	508	2,70586	542	2,73400
441	2,64444	475	2,67669	509	2,70672	543	2,73480

A Table of Logarithmes.

N	Logar.	N	Logar.	N	Logar.	N	Logar.
544	2,73560	578	2,76193	612	2,78675	646	2,81023
545	2,73640	579	2,76268	613	2,78746	647	2,81090
546	2,73719	580	2,76343	614	2,78816	648	2,81157
547	2,73799	581	2,76418	615	2,78887	649	2,81224
548	2,73878	582	2,76492	616	2,78958	650	2,81291
549	2,73957	583	2,76567	617	2,79028	651	2,81358
550	2,74036	584	2,76641	618	2,79099	652	2,81425
551	2,74115	585	2,76716	619	2,79169	653	2,81491
552	2,74191	586	2,76790	620	2,79239	654	2,81558
553	2,74272	587	2,76864	621	2,79309	655	2,81624
554	2,74351	588	2,76938	622	2,79379	656	2,81690
555	2,74429	589	2,77011	623	2,79449	657	2,81756
556	2,74507	590	2,77085	624	2,79518	658	2,81822
557	2,74585	591	2,77159	625	2,79588	659	2,81888
558	2,74663	592	2,77232	626	2,79657	660	2,81954
559	2,74741	593	2,77305	627	2,79727	661	2,82020
560	2,74819	594	2,77379	628	2,79796	662	2,82086
561	2,74896	595	2,77452	629	2,79865	663	2,82151
562	2,74973	596	2,77525	630	2,79934	664	2,82217
563	2,75051	597	2,77597	631	2,80003	665	2,82282
564	2,75128	598	2,77670	632	2,80072	666	2,82347
565	2,75205	599	2,77743	633	2,80140	667	2,82413
566	2,75282	600	2,77815	634	2,80208	668	2,82478
567	2,75358	601	2,77887	635	2,80277	669	2,82543
568	2,75435	602	2,77960	636	2,80346	670	2,82607
569	2,75511	603	2,78032	637	2,80414	671	2,82672
570	2,75587	604	2,78104	638	2,80482	672	2,82737
571	2,75664	605	2,78175	639	2,80550	673	2,82801
572	2,75740	606	2,78247	640	2,80618	674	2,82866
573	2,75815	607	2,78319	641	2,80656	675	2,82930
474	2,75891	908	2,78390	642	2,80753	676	2,82995
575	2,75967	609	2,78462	643	2,80821	677	2,83059
576	2,76042	610	2,78533	644	2,80889	678	2,83123
577	2,76118	611	2,78604	645	2,80956	679	2,83187

A Table of Logarithmes.

N	Logar:	N	Logar:	N	Logar.	N	Logar
680	2,83251	714	2,85370	748	2,87390	782	2,89321
681	2,83315	715	2,85431	749	2,87448	783	2,89376
682	2,83378	716	2,85491	750	2,87506	784	2,89431
683	2,83442	717	2,85552	751	2,87564	785	2,89487
684	2,83506	718	2,85612	752	2,87622	786	2,89542
685	2,83569	719	2,85673	753	2,87679	787	2,89597
686	2,83632	720	2,85733	754	2,87737	788	2,89653
687	2,83696	721	2,85793	755	2,87795	789	2,89708
688	2,83759	722	2,85854	756	2,87852	790	2,89763
689	2,83822	723	2,85914	757	2,87910	791	2,89818
690	2,83885	724	2,85974	758	2,87967	792	2,89872
691	2,83948	725	2,86034	759	2,88024	793	2,89927
692	2,84011	726	2,86094	760	2,88081	794	2,89982
693	2,84073	727	2,86153	761	2,88138	795	2,90037
694	2,84136	728	2,86213	762	2,88195	796	2,90091
695	2,84198	729	2,86273	763	2,88252	797	2,90146
696	2,84261	730	2,86332	764	2,88309	798	2,90200
697	2,84323	731	2,86392	765	2,84361	799	2,90255
698	2,84385	732	2,86451	766	2,88423	800	2,90309
699	2,84448	733	2,86510	767	2,88479	801	2,,0363
700	2,84510	734	2,86570	768	2,88536	802	2,90417
701	2,84572	735	2,86629	769	2,88592	803	2,90472
702	2,84634	736	2,86688	770	2,88649	804	2,90526
703	2,84695	737	2,86747	771	2,88705	805	2,90580
704	2,84757	738	2,86806	772	2,88762	806	2,90633
705	2,84819	739	2,86864	773	2,88818	807	2,90687
706	2,84880	740	2,86923	774	2,88874	808	2,90741
707	2,84942	741	2,86982	775	2,88930	809	2,90795
708	2,85001	742	2,87040	776	2,88986	810	2,90848
709	2,85065	743	2,87099	777	2,89042	811	2,90902
710	2,85126	744	2,87157	778	2,89098	812	2,90956
711	2,85187	745	2,87216	779	2,89154	813	2,91008
712	2,85248	746	2,87274	780	2,89209	814	2,91062
713	2,85309	747	2,87332	781	2,89265	815	2,91116

A Table of Logarithmes.

N	Logar.	N	Logar.	N	Logar.	N	Logar.
816	2,91169	850	2,92942	884	2,94645	918	2,96284
817	2,91222	851	2,92993	885	2,94694	919	2,96331
818	2,91277	852	2,93044	886	2,94743	920	2,96379
819	2,91328	853	2,93095	887	2,94792	921	2,96426
820	2,91381	854	2,93146	888	2,94841	922	2,96473
821	2,91434	855	2,93197	889	2,94890	923	2,96520
822	2,91487	856	2,93247	890	2,94939	924	2,96567
823	2,91540	857	2,93298	891	2,94988	925	2,96614
824	2,91593	858	2,93349	892	2,95036	926	2,96661
825	2,91645	859	2,93399	893	2,95085	927	2,96708
826	2,91698	860	2,93450	894	2,95134	928	2,96755
827	2,91751	861	2,93500	895	2,95182	929	2,96802
828	2,91803	862	2,93551	896	2,95231	930	2,96848
829	2,91855	863	2,93601	897	2,95279	931	2,96895
830	2,91908	864	2,93651	898	2,95328	932	2,96941
831	2,91960	865	2,93701	899	2,95376	933	2,96988
832	2,92012	866	2,93752	900	2,95424	934	2,97035
833	2,92064	867	2,93802	901	2,95472	935	2,97081
834	2,92117	868	2,93852	902	2,95521	936	2,97128
835	2,92169	869	2,93902	903	2,95569	937	2,97174
836	2,92221	870	2,93952	904	2,95617	938	2,97220
837	2,92272	871	2,94002	905	2,95664	939	2,97267
838	2,92324	872	2,94052	906	2,95713	940	2,97313
839	2,92376	873	2,94102	907	2,95761	941	2,97359
840	2,92428	874	2,94151	908	2,95809	942	2,97405
841	2,92480	875	2,94201	909	2,95856	943	2,97451
842	2,92531	876	2,94250	910	2,95904	944	2,97497
843	2,92582	877	2,94300	911	2,95952	945	2,97543
844	2,92634	878	2,94349	912	2,95999	946	2,97589
845	2,92686	879	2,94399	913	2,96047	947	2,97635
846	2,92737	880	2,94448	914	2,96095	948	2,97681
847	2,92788	881	2,94498	915	2,96142	949	2,97727
848	2,92840	882	2,94547	916	2,96189	950	2,97772
849	2,92891	883	2,94596	917	2,96237	951	2,97818

A Table of Logarithms.

N	Logar.	N	Logar.	N	Logar.	N	Logar.
952	2,97864	964	2,98408	976	2,98945	988	2,99476
953	2,97909	965	2,98453	977	2,98989	989	2,99520
954	2,97955	966	2,98498	978	2,99034	990	2,99563
955	2,98000	967	2,98543	979	2,99078	991	2,99607
956	2,98046	968	2,98587	980	2,99113	992	2,99651
957	2,98091	969	2,98632	981	2,99167	993	2,99695
958	2,98137	970	2,98677	982	2,99211	994	2,99739
959	2,98182	971	2,98722	983	2,99255	995	2,99782
960	2,98227	972	2,98767	984	2,99299	996	2,99826
961	2,98272	973	2,98811	985	2,99344	997	2,99869
962	2,98317	974	2,98856	986	2,99388	998	2,99913
963	2,98363	975	2,98900	987	2,99432	999	2,99956
						1000	3,00000

An Explanation of the former Table of Logarithms.

EVery Page in the former Table of Logarithms is divided into eight Columnes, or ſpaces, whereof the 1, 3, 5, and 7th. having the letter N at the head thereof are the Numbers ſucceſſively continued from 1. to 1000. ſo that to finde the Logarithm of any number under 1000, you muſt finde the number given, and againſt the ſame towards the right hand you have the Logarithm thereof.

Example. Suppoſe the number given be 720, and its Logarithm is required; therefore in the third Row, under the Title N, I ſeek the ſaid number, and againſt the ſame ſtands 2,85733, which is the Logarithm deſired.

But if a Logarithm be given, and the abſolute number thereto belonging is required, then ſeek out the Logarithm under the Title, and againſt

the ſame towards the left hand, is the abſolute number anſwering to that Logarithm.

If you cannot finde in the Table the juſt Logarithme you ſeek for, you muſt take the neereſt thereunto; or in the Table of Sines and Tangents, you may (if you pleaſe) make proportion, ſo ſhall you take the Logarithme to a Minute, but in ſuch caſes your own judgement may beſt inform you.

The end of the Second Book.

The ART of SURVEYING.

The Third Book.

Wherein is contained the menſuration of the Superficial content, or Area, of any Figure, Plot, Piece of Ground, Map, or the like, of what form or Proportion ſoever.

ALthough the Triangle is the moſt perfect and abſolute of all Geometrical figures, as I have declared at large elſewhere, yet in regard (as one well obſerves) that the meaſuring as well of the Triangle, as all other figures, is demonſtrated out of the Square and Oblong, or long Square, I ſhall there-

therefore in the first place, begin with the Square, and the rather, because it is the most easie to measure of all Geometrical Figures.

PROBL. I.

To measure the Area, or Superficial content of a Square.

EVery Square is a Rectangled equilater Parallelogram, whose sides are all equal, as this Figure demonstrates.

A Square is thus measured. Multiply the side in it self, and the product is the Area. Example, Multiply A B, one of the sides 20 Perches, Yards, or Feet, in it self, and it maketh 400, for the Area, or Superficies of the Square A B C D.

Or double the Logarithm of the side, and the sum is the Logarithm of the Area.

The given side 20.	1,30103
The Area 400. as before.	2,60206

To finde the length of the Diagonal B D, multiply the side in it self, as before, then double the Product, and the square root thereof will be the length of the Diagonal.

Example. Let the figure ABCD be the square, whose Diagonal B D is required. The side thereof being 20, the square is 400, the double thereof 800, whose square root is 28.28, which is the length of the Diagonal.

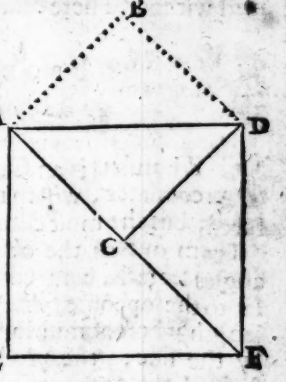
Logar.

Logar. 20. Rad. adde. 11,30101
Sine of the angle A B D 45, deg. 9,84948

Log. of the Diagonal B D 28.283. 1,45153

Again, if you ſquare the Diagonal, half that number ſhall be the content, or Area of the ſquare.

Example. Suppoſe ABCD be the ſquare given, and let the other ſquare AEFD be made ſo, as the ſide thereof may contain the length of that Diagonal AD, then will the Diagonal of the greater ſquare A F contain 40, the ſquare whereof is 1600. whoſe half 800, is the Area, or ſuperficial content of the ſquare AEFD, which is double to the ſquare ABDC, whoſe content is 400.

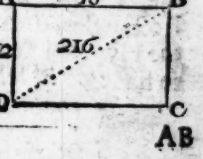


PROBL. II.

To meaſure the long Square.

THe long ſquare, or Oblong is a Rectangled Parallelogram not equilater, as this figure expreſſeth

To meaſure an Oblong, multiply the length by the breadth, and the factus is the Area, or content.



Example, Multiply AD 12, in

AB

AB 18, and the product 216 is the Area, or content of the Oblong *A B C D*.

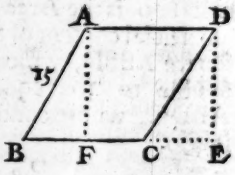
To finde the length of the Diagonal B D, ſquare *A B* 18, and *A D* 12, which added together, the ſquare root thereof will be yout deſire.

It may be meaſured by Logarithmicall ſupputation, but ſeeing it may more readily be performed without, I here omit it.

PROBL. III.

To meaſure a Rhombus.

A Rhombus is an Obliquangled Parallelogram equilater, which may ſundry ways be meaſured, but the moſt common way is thus.



From one of the obtuſe angles let fall a perpendicular to the oppoſite ſide, the length whereof multiplyed by the ſide, the product ſheweth the Area.

Firſt, to finde the length of the perpendicular, ſuppoſe a line drawn from *A* to *C*, which will divide the Rhombus into two equilateral equiangled Triangles, namely *A B C*, and *A C D*, then from the obtuſe angle *A*, let fall the perpendicular upon the line *B C* in the point F, whereby the Triangle *A B C* is divided into two Triangles-Rectangles, then in the Rectangled Triangle *ABF*, the Hypotenuſe *A B* is 15,00, and the Leg BF 7.50, to finde *A F*.

By

By the 7. Probl. *of Rectang. Triang.*

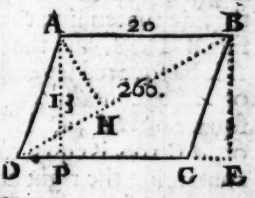
AB 15,00	Sum. 22.50.		1,35218
BF 7,50	Diff. 7.50.		0,87506
		Aggregate	2,22724
AF 12,99.		Semiaggreg.	1,11362

Next to finde the area, I multiply the side BC 15, by the Perpendicular A F 12. 99, and the Product 194. 85, is the area or superficial content of the Rhombus.

PROBL. IV.

To measure a Rhomboides.

A Rhomboides is an Obliquangled Parallelogram, not equilater, as is represented by this figure.



A Rhomboides may be measured two manner of ways. First, from one of the Obtuse angles draw a Perpendicular to the opposite side, which Perpendicular multiplyed by one of the longer sides, sheweth the area.

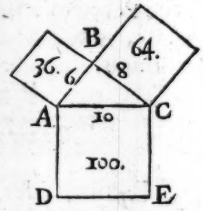
Example. Let *A B C D* be the Rhomboides given, whose side *AB* 20, multiplyed by the Perpendicular *A P* 13, produceth 260, for the Area of the Rhomboides *A B C D*.

Or, secondly it may be reduced into two Triangles by the line B D, and so measure them as an *Ambligonium Scalenum*, for if you multiply the Diagonal B D by the Perpendicular AH, it produceth the Area of the Rhomboides.

PROB.

PROBL. V.

In all plain Rectangled-Triangles, the square of the side subtending the right angle, is equal to the squares made of the sides containing the right angle.



FOr the better elucidation of some succeeding Problems, I thought this necessary to be inserted, as being the ground and foundation whereon the dimension of right-lined Triangles Rectangles do principally depend.

Suppose therefore the Triangle given be *ABC*, right angled at *B*; and let the side subtending the right angle B be 10, the side B C be 8, and the side *A B* be 6. Now if every side be squared severally, we shall finde the square of *AC* to contain 100, the square of BC 64, and the square of *A B* 36. Hence it appears, that the square of *A C* 100. is equal to both the squares of the sides containing the right angle AB and BC 100. which was to be shewed.

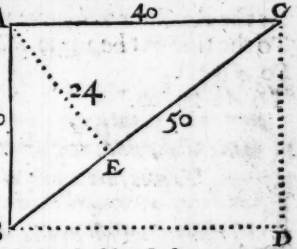
PROBL. VI.

To measure Right-Angled Triangles.

Parallelogrammum est duplum Trianguli, Basi & Altitudine æqualis E. 41. p. 1. Hence it follows that a Rectangled-Triangle is half that long square whose length and bredth are equal to the two containing sides thereof. As in this figure, *A B C* is

equal

equal to half the long ſquare *ABDC*.



Multiply one of the ſides containing the right angle, in the half of the other, and you have the content. Or multiply the two ſides containing the Right angle together, and the half of that product is the Area.

Or elſe, multiply the half of the Baſe B C, by the perpendicular AE, and it produceth the area.

Example. Suppoſe *A B C* be the Right-angled Triangle, whoſe area, or ſuperficial content is required; therefore I multiply the ſide *A B* 30, by half the ſide *A C* 20, and the Product 600. is the area thereof.

Or 40 multiplied by 30 produceth 1200, whoſe half is 600, for the content thereof.

Otherwaies, if you multiply half the Baſe B C 25, by the perpendicular AE 24, the product is 600, as before.

To finde the third ſide of a right angled-triangle, ſquare each ſide ſeverally containing the right angle, and the ſquare root of their aggregate yieldeth the third ſide.

As in our example, the ſquare of the ſide AC 40, is 1600, and the ſquare of the ſide *A B* 30, is 900, the aggregate is 2500, whoſe root 50, is the third ſide BC. The Demonſtration hereof is delivered in the preceeding Probleme.

Laſtly, the perpendicular *AE* may be thus found bythe ſecond Probl. of Triang. Rectang.

As

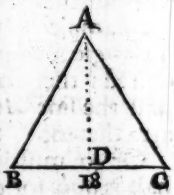
As the Radius 90. degrees	10,00000
To the ſine of the angle *ABE* 53*d*. 7′. 49″.	9,90309
So *AB* 30.00	1,47712
To *AE* 24. 00.	1,38021

PROBL. VII.

To meaſure an Equilateral-Triangle.

SI Triangulum eſt æquilaterum, eſt quoque æquiangulum, R. 2. conſ. 10. c. 6.

An equilateral Triangle is that whoſe ſides are all of equal length, and its angles equal, as the annexed figure ſhews.



It may be meaſured by letting fall a perpendicular from either angle to the oppoſite ſide, and then by multiplying the half of the one in the whole of the other. But the uſual way is to multiply half one of the ſides in it ſelf, and the product by that half again, and that number ſo produced, multiply in half the Perimeter, and the ſquare root of that product, ſheweth the area of the Triangle.

Example. Suppoſe *ABC* be an equilateral Triangle, each of whoſe ſides is 18, the half is 9, his ſquare 81. multiplied by 9, is 729, which being multiplied by half the Perimeter 27, maketh 19683. whoſe ſquare root 140.30, is the area of the Triangle.

Then if you deſire the length of the perpendicular, ſubſtract the ſquare of half the ſide from the ſquare of the whole ſide, and the ſquare root of the remainer is the perpendicular.

Example.

Example. The ſide of the Triangle is 18, whoſe ſquare is 324, and the half of 18 is 9, whoſe ſquare is 81, which taken from 324, there reſteth 243, whoſe root is 15.589.

Then if you multiply the perpendicular *AD* 15.589, by half the Baſe BC 9, it giveth the area or content of the Triangle 140.30, as before.

Or by Trigonometry thus.

Firſt finde the perpendicular *AD*.

In the Rectangled Triangle *A C D* we have given, *BD* 9, and the Hypotenuſe *AB* 18, to find *AD*.

Hypotenuſe *AB* 18	Sum.	27	1,43136
Leg BD 9	Differ.	9	0,95424
		Aggregate	2,38560
Perpend. *AD* 15.589.		Semiagreg.	1,19280

Then to finde the area of the Triangle *ABC*.

Perpendicular *AD* 15,589.	1,19280
Semibaſe *BD* 9.00	0,95424
Area of the Triangle *ABC* 140.30.	2,14704

PROBL. VIII.

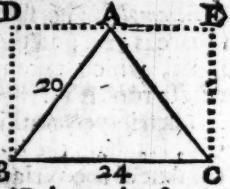
To meaſure an Iſoſceles Triangle.

THis figure (like the former) hath three acute angles, and but two equal ſides, the angles being equal at the Baſe, as this figure demonſtrates.

Every Iſoſceles is half the long ſquare, whoſe length and breadth is equal to the unequal ſide, and perpendicular which cutteth the ſame. And this triangle may be meaſured two manner of waies.

1. From

1. From the ſquare of one of the equal ſides, ſubſtract the ſquare of half the unequal ſide, and the ſquare root of the remainer multiplied in half the unequal ſide produceth the area.



Example. The equal ſide *AB* is 20, its ſquare 400, the half of the unequal ſide is 12, and its ſquare 144, which ſubſtracted from the ſquare of *AB* 400, leaveth 256, whoſe root 16, being multiplied by half the unequal ſide BF 12, produceth 192, for the area, or ſuperficial content of the Triangle *ABC*.

Now if you deſire to finde the perpendicular, ſubſtract the ſquare of half the unequal ſide, out of the ſquare of the equal ſide, and the ſquare root of the remainer is the perpendicular.

Example. The ſquare of the equal ſide is 400, and the ſquare of half the unequal ſide is 144, which taken out of the former, there reſteth 256, whoſe ſquare root is 16, the length of the perpendicular *AF*.

Now if you multiply the perpendicular *AF* 16, by half the Baſe BF 12, the product 192. is the area, as before.

By Trigonometrical ſupputation it may be thus performed.

1. For the perpend. *AF*			2. For the area.		
AC 20	3 2	1,30515	*AF* 16		1,20412
FC 12	5 8	0,90309	*FC* 12		1,07918
		2,40824	Area 192		2,28330
AF 16		1,20412	As before		

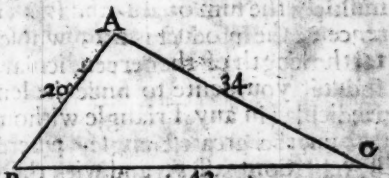
PROBL.

PROBL. IX.

To measure any manner of Triangle without finding the perpendicular.

SI dati Trianguli latera ſigillatim inventa colligantur, & ab hujus collecti dimidio latera ſingula ſubducantur; latus continuè factis è dato dimidio & reliquis, erit area Trianguli.

Therefore, add all the three ſides of the Triangle together, and of the total take half, then ſee what each ſide differs from that half, which done, multiply that half by one of the differences, and the product thereof, multiply by any of the other differences, and the factus again multiplied by the third difference, the ſquare root of the totall is the Area.



Example. The three ſides of this triangle are 42. 34. 20. the ſum is 96. the half ſumme 48, from which taking the ſides ſeverally, the differences are 28. 14. 6. Firſt multiply 48. by 28. and the product is 1344. which multiply by 14. and the off-come is 18816, this multiply by the laſt difference 6. and the product is 112896, whole root 336. is the Area of the Triangle.

If you pleaſe to work by Logarithms, then to the Logarithm of half the ſum of the ſides add the Logarithms of the differences of each ſide ſeverally,

from that half sum, and the Aggregate of those Logarithms bisected, is the Logarithm of the Area of the Triangle.

Example.

The half sum of the sides	48.	1,68124
The Differences of each side severally from the half sum of the sides are	28.	1,44716
	14.	1,14613
	6.	0,77815
		5,05268
Area of the Triang'e *A B C* 336. 00.		2,52634

To finde the length of the Perpendicular, multiply the sum of the two sides AC and AB 54, by their difference 14, and the product 756, divide by the Base BC 42, the quotient is 18, which subtracted from the Base 42, there remaineth 24, whose half is the length of the left Section B D 12, then multiply the sum of *A B* and BD 32, by their difference 8, the product is 256, whose square root is 16, the length of the perpendicular *A D*.

But if you desire to finde the length of the perpendicular in any Triangle without Arithmetick, seek out the greatest angle, wherein set one foot of your Compasses, and with the other take the shortest extention between that and the Base-line, which wideneſſe of your Compasses, apply unto your Scale, which will tell you (without any further trouble) the just length of the perpendicular in Perches, according to the Scale you took it by; and this, as it is the most beaten and common way used in Surveying, so is it exact enough for busineſs of that nature, and more expeditious than any other.

PROBL.

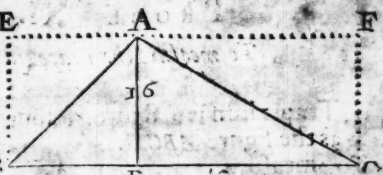
PROBL. X.

To measure any manner of Triangle otherwise then is shewed in the last Problem.

EVery Triangle is half that long square, whose length and breadth is equal to the perpendicular and side cut by the perpendicular, as is evident by this figure.

Si duo trianguli latera conterminia, angulum rectum comprehendentia, separatim sive conjunctim, in latus angulos utrimque rectos faciens ducantur, & facti summatur dimidium: illud constituet aream trianguli rectanguli.

Therefore from one of the greatest angles draw a perpendicular (as I shewed before) which multiply in half the Base, or side cut thereby, and the Product is the area.



Or else, multiply the whole Base by half the perpendicular, and the product will shew the content.

Or if you multiply the whole Base by the whole perpendicular, take half of the Product for the area.

Example. Admit *A B C* be a Triangle to be measured. The Base BC is 42 Perches and the Perpendicular *A D* 16 (as they are both taken from the Scale) now I multiply the half Base 21, by the

whole perpendicular 16, and the product 336, is the area of the Triangle *ABC*.

Or if you multiply the whole Base 42, by half the perpendicular 8, the product will be 336, as before.

Or else multiply the whole Base 42, by the perpendicular 16, the product will be the content of the long square E F C B 672, whose half is 336, the area of the Triangle, as before.

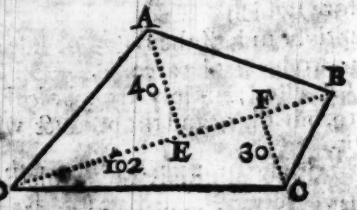
Or Logarithmetically.

Half the Base BC 21.	1,32222
The Perpendicular AD 16.	1,20412
Atea of the Triangle ABC 336	2,52634

PROBL. XI.

To measure the Trapezium.

A Trapezium is a figure of four unequal sides, as the figure *ABCD*.



To measure the Trapezium, draw the Diagonal B, so is the figure divided into two Triangles, which you may measure according to the last Problem, by letting perpendiculars fall from the angles *A* and *C* upon the Base B D.

But with more brevity, you may add the two perpendiculars together, and multiply the sum of them

them by half the Baſe, and the product will be the area of the Trapezium *A B C D*.

Example. The ſum of the two perpendiculars are 70, and the half of the Baſe is 51, which multiplyed together, make 3570, for the area of the Trapezium *A B C D*.

By the Table of Logarithms.

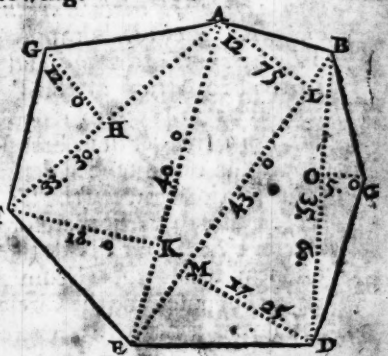
Sum of the perpendiculars AE & CF is 70.	1,84510
Half of the Baſe BD is 51.	1,70757
The area of the Trapezium *ABCD* 3570	3,55267

PROBL. XII.

To meaſure any irregular figure, or Plot of ground taken upon the Plain-Table.

FIrſt, reduce it into Trapezias and triangles, by drawing lines from one angle to another, as we ſhall exemplifie in the adjunct Diagram, and the example following.

Suppoſe this figure noted with the letters ABCDE FG, be the form of an irregular Field drawn upon the Plain-Table; and becauſe it is not in any of the ſhapes before



F 3 deſcr

described, therefore the best way is to reduce it into Trapezias and triangles, which is effected by drawing the lines AF, A E, B E, and BD, so is the figure divided into three triangles and one Trapezium, namely the triangles AGF, AEF, BCD, and the Trapezium *A B D E*.

Now to finde the content of this figure, I measure the Trapezium and triangles, in such manner as is before shewed, and the sum will be the area of the whole field, as by the example appears.

Trapezium	*A B D E*	645.	00.
Triangles	*A F G*	199.	80.
	A F E	360.	00.
	B G D	89.	00.
The area of the figure *ABCDEFG.*		1293.	80.

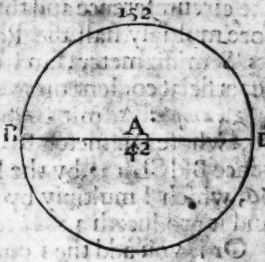
Probl. XIII.

The Diameter of a Circle being given, to finde the Circumference.

Peripheria circuli est tripla Diametri, & fere sesquiseptima, Ra. 2. c. 19. But more exactly, according to *Ludovicus Van Ceulen*, and other Geometricians, the Proportion of the Periphery to the Diameter, is as 314159, to 100000. But that we may take it in smaller numbers (which will be more proper for our intended design) the neerest rational proportion between the Diameter and circumference is as 7 to 22, if therefore you multiply the Diameter by 22, and divide the Product by 7, the Quotient will shew the Circumference.

Example. Suppose A be the Circle given, whose circumference is required; therefore I multiply the

the Diameter B D 42, by 22, and the product 924, I divide by 7, the quotient is 132, which is the Periphery, or circumference of the circle *A*.



But if the circumference of a Circle be given, and it be required to finde the Diameter; multiply the circumference by 7, and divide the product by 22, the Quotus sheweth the Diameter.

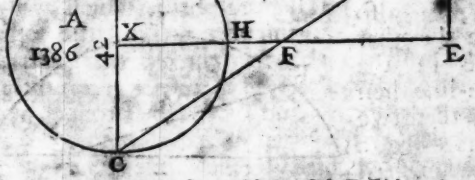
Example. I multiply the circumference 132, by 7, and the product 924, I divide by 22, the Quotus 42, is the Diameter of the Circle BD.

PROBL. XIV.

To measure a Circle.

PLanus sive Quadratus è radio & Peripheriæ dimidio, dabit aream circuli, R.a.1.con.2.c.19.

A Circle is neer equal to the Oblong, or long



square, whose length and breadth are equal to half

the circumference and that Semidiameter: wherefore multiply half the Perimeter of the Circle by its Semidiameter, and the Product will shew the superficial content or area of that Circle.

Example. Admit *A* be the Circle to be measured, whose Diameter BC is 42, and the circumference BHCB 132, by the last Problem, whose half is 66, which I multiply by the Semidiameter B X 21, and it produceth 1386, for the area of the Circle.

Or if you add the Logarithm of 66. to the Logarithm of 21. the sum is the Logarithm of the area of the Circle.

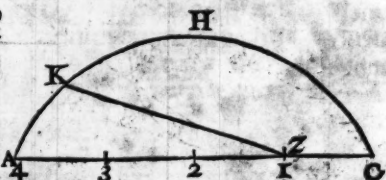
Or, multiply the Diameter 42, by the fourth part of the circumference 33, and it doth produce 1386, for the content of the Circle, as before.

Here you may see also, that the Oblong BDEX is neer equal to the Circle *A*, as likewise the Rectangled triangle CBD.

PROBL. XV.

To finde the length of an Arch-line Geometrically.

LEt the Chord-line be divided into four equal parts, and with your Compasses set one of these parts; from one of the angles in the Chord-line, which extent set also from the other angle in the Arch-line, then from these two points draw a line, which shall be equal to half the Arch-line required.

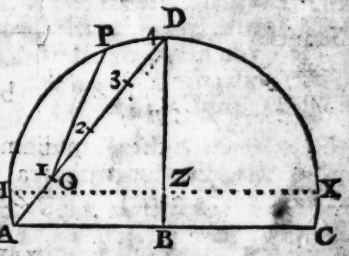


length

Example. Suppose AHC be an Arch-line, whose length is repuired. To perform this, I divide the Chord AC into 4 equal parts, and one of these parts I set from C towards A, to Z, the same part I set in the Arch-line from A to K, then I draw the line ZK, which is one half of the Arch-line AHC, whose double shall be the whole Arch-line required.

But if the portion of the given Circle, be greater then a Semicircle, divide the Arch-line into two equal parts, then finde the length of one of those parts, as before, which doubled, giveth the length of the Arch-line.

Example. Let *ADC* be a portion of a Circle given, greater then a Semicircle, whose extent is desired. First therefore I divide the said arch into two equal parts, by the line BD, then I divide the Chord-line *AD* into four equal parts, by help whereof I draw the line OP, as we shewed in the first example hereof, which line is half the Arch *AD*, and by consequence four times the line OP is equal to the Segment of the Circle *ADC*.



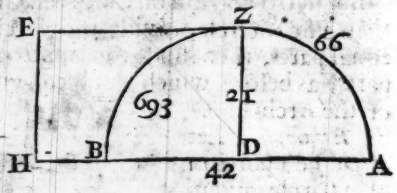
PROBL.

PROBL. XVI.

To measure a Semicircle.

EVery Semicircle is neer equal to that long square, whose length and breadth is equal to half the Arch-line, and the Semidiameter.

Multiply half the Arch line by the Semidiameter, and the product is the area of the Semicircle.



Example. Suppose the half Circle *AZB* is to be measured, whose Arch-line *AZB* is 66, now I multiply the half thereof 33, by the Semidiameter *ZD* 21, and it produceth 693, for the area of the Semicircle *AZB*, to which the Oblong *ZEHD* is neer equal.

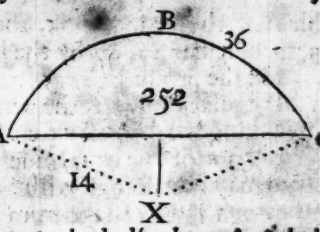
PROBL. XVII.

To measure a Sector, Segment, or Portion of a Circle.

EVery Sector of a Circle is neer equal to that long square, whose length and breadth is equal to the Semidiameter and half the Arch line.

First, finde out the center of that Circle, whereof the Arch-line is a part of the Periphery, by the 8 Problem of the first Book, then multiply half the the Arch-line, by the Semidiameter, and the Product

duct sheweth the area.



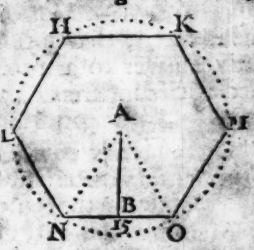
Example. Let *A B C* be a prótion of a Circle to be measured. The Arch-line *ABC* is found by the fifteen Problem, to be 36, the half whereof 18, being multiplyed by the Semidiameter XA 14, produceth for the area of the Sector *ABC* 252.

PROBL. XVIII.

To measure any regular Poligon, or Multilater.

EVery regular Poligon is equal to that long square, whose length and breadth is equal to half the Perimeter, and the perpendicular drawn from the center to the middle of any of the opposite sides.

Si fiat planus, è perpendiculari à centro in latus & dimidio perimetri; factus est area multanguli ordinati, Ra. 1.c.19. Therefore from the center to one of the sides draw a perpendicular by the 5. Problem of the 1. Book, which perpendicular multiply in half the Perimeter, and the product will shew the content.

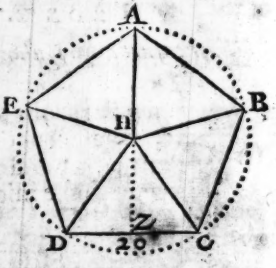


Example. In the Hexagon HKMONL, every side is 15, and the perpendicular A B 12,99, by the first Problem

Problem of the second Book, therefore I multiply the perpendicular 12, 99, by the half of the Perimeter 45, and the product 584, 55. is the area.

In all regular Poligons the perpendicular may be had by taking the shortest extentation between the center and one of the equal sides, which in Land-measure may be effected with Scale and Compass, but more exactly by the admirable Doctrine of artificial Trigonometry, according to the second Book, 3 Sect. 1. Prob. of Triang. Rectangle.

Example. Let this figure noted with the letters *A B C D E* be a Pentagon, consisting of five equal Isosceles Triangles meeting vertically in the center of the said Pentagon at H, whose sides are the rays of the circumscribed Circle, and the Bases, the sides of the Pentagon. As in the Isosceles triangle CHD, the equilateral sides HC and H D, are two Raies of the Pentagons Circumambient Circle, and CD the Base of the Isosceles, therefore the angle C H D, doth exactly answer to a fifth part of the circumscribed circles circumference, which is 72 degrees, then letting fall a perpendicular from the vertical angle H, cutting the line C D at right angles in Z, we shall have the Isosceles divided into the two Rectangle triangles CHZ and DZH, whose vertical angles CHZ and DHZ are each of them 36 degrees. And seeing all the angles are given, with the lesser side C Z equal D Z 10, we may by the first



first Problem of Triang. Rectang. finde the other side H Z, after this manner.

As the sine of the angle CHZ 36*d*. 0′.	9,76922
To CZ 10.	1,00000
So the sine of the angle CHZ 54. 0.	9,90796
To H Z 13. 76.	1,13874

The Perimeter of the Pentagon is 100 whose half 50, being multiplyed by the perpendicular 13,76, produceth 688, for the area of the Pentagon A B C D E.

We will here take the Example set down by *Ramus*, *Orontius*, Dr. *Ryff*, and others, where the sides of the Pentagon are 12. First to finde the perpendicular H Z.

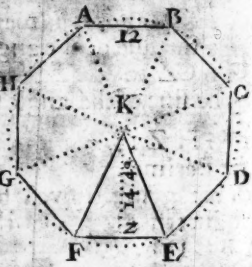
As the sine of the angle CHZ. 36*d*. 0′.	9,76922
To CZ 6.	0,77815
So the sine of the angle H C Z 54*d*.	9,90796
To H Z 8. 258.	0,91689

Whereas *Ramus* makes it onely 8, and to him assents *Orontius Geom. Pract. cap.* 24: and *P. Ryff*, *Geomet. cap.* 2. *part.* 2. who taking it upon trust one from another (as the Learned Dr. *Wybard* observes) they make the area of the ordinate Pentagon but 240, whereas the true area is 247. 74.

But in the Hexagon whose Perimter is 36, the perpendicular will be found to be 5, 196, and the area 93. 528. and herein Dr. *Ryff* comes neer the truth, as may be seen *Part.* 2. *cap.* 6. *Geomet.* where he maketh the perpendicular 5. $\frac{2}{11}$ and consequently the area of the Hexagon 93. $\frac{3}{11}$.

After the same manner are all regular Poligons to be measured, as the Heptagon, Octagon, Encagon, Decagon, or the like, but we shall for brevity sake onely add one example more. In

In the Octagon ABCDEFG describe the Isosceles Triangle EKF wherein the sides EK, and KF are two Raies of the Octagons circumscribed Circle, and the side EF 12, the Base of the Isosceles, and because the angle EKF in the center of the Octagon or figure of 8 sides, is one eight part of



the ambient circles circumference 360 degrees, to wit 45 degrees, therefore the half thereof 22 degrees 30 minutes is equal to the angle EKZ.

Then in the Triangle EKZ, all the angles being given, with the side EZ 6, we may (as before) finde the perpendicular KZ.

Sine of the angle EKZ 22*d.* 30′.	9,58284
EZ 6.	0,77815
Sine of the angle KEZ 67*d.* 30′.	9,96562
	10,74377
ZK 14: 48.	1,16093

The perpendicular now found, I multiply half the Perimeter 48, in the perpendicular 14. 48, and the product 695. 40. is the area of the Octagon ABCDEFGH.

Or by artificial numbers.

Half the Perimeter 48.	1,68124
Perpendicular 14. 48.	1,16077
Area 695.04 as before.	2,84201

The end of the Third Book.

The ART of SURVEYING.

The Fourth Book.

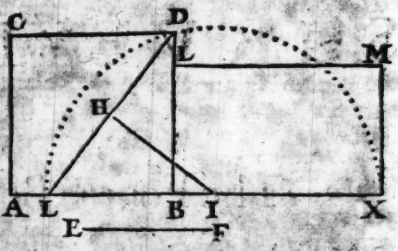
WE intended in this place to ſhew the Reader how to perform Geometrically the Rules of Reduction, Addition, Subſtraction, Multiplication, Diviſion, and the Rule of Proportion in Lines, but in regard they are not of abſolute neceſſity for a Surveyor, and beſides would take up much room, and ſo exceed the Scale and Compaſs of intended limits, I ſhall therefore in this Book Treat onely of the former, which is of Reduction, and the rather becauſe it is of more uſe in Surveying than any of the reſt (unleſs it be Diviſion, of which we ſhall ſpeak of afterward) whereby all manner of figures may ſpeedily be reduced from one

one form to another, retaining ſtill the ſame quantity and proportion.

PROBL. I.

To reduce a Geometrical Square into a long Square, whoſe breadth is limited by a right line given.

Suppoſe A B C D be a Geometrical Square, to be reduced into a long ſquare, whoſe breadth is equal to the line E F. Firſt, continue the ſide of the ſquare A B towards X, and ſet the given breadth of the long ſquare E F from B to L then drawing the line L D, let it be divided into two equal parts at right angles by the line H I, which perpendicular line cutteth the line L X in I, on which point I, with the diſtance I L deſcribe the Semicircle L D X, which cutteth the ground-line in X, ſo is B X the length of the long ſquare deſired, with which length and the given breadth E F deſcribe the long ſquare B L M X by the Problem of the firſt Book, which will be equal to the given ſquare, as was required.

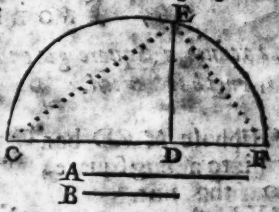


PROBL.

PROBL. II.

To finde a mean proportional line between any two lines given.

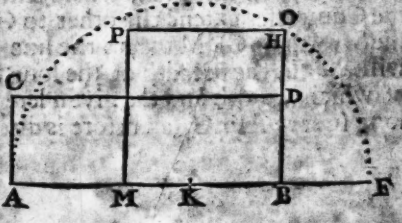
SUppose A and B be the two lines given, between which it is required to finde a mean proportional line, therefore let the two lines given be joyned togeather to make one straight line, as C D F touching each other in the point D, then with half the distance C F describe the Semicircle CEF, and on the point D by the 3. Problem of the first Book, raise the perpendicular to cut the circumference in E, as E D, which shall be the mean proportional required.



PROBL. III.

To reduce a long Square into a Geometrial Square.

LEt A B C D be a long square to be reduced into a Geometrical square. First, set the breadth B D from B to F,



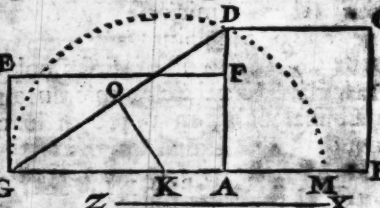
and

and continue the line B D towards H, then take half the line A F and mark the point K, which done, with the extent K A or K F, describe the Semicircle A O F, which cutteth the perpendicular in O, so shall O B be the side of the square, whose square P M B O is equal to the long square A C D B, which was required.

PROBL. IV.

To reduce a Square given into a long Square, whose length is limited.

Suppose A B C D be a square given, to be reduced into a long square, whose length shall be equal to the line Z X. First continue the line B A towards G, and set the line Z X from A to G, drawing the line D G, on the middle whereof erect the perpendicular O K, to cut the ground-line in K, where setting one foot of the Compasses, extend the other to G, and describe the Semicircle G D M to cut the line G B in *M*, so will *A M* be the breadth of the long square sought, of which breadth and the given length, make the long square A F E G, as before is directed.

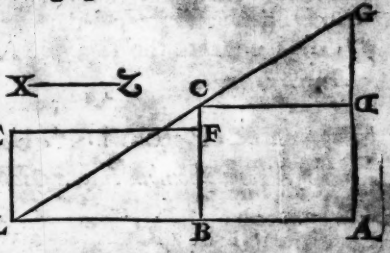


PROBL.

PROBL. V.

To reduce one long Square into another long Square, whose breadth is limited.

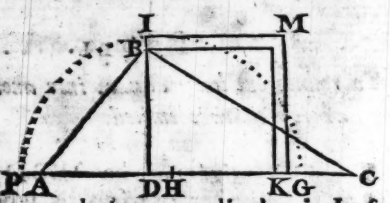
LEt the long ſquare be ABCD, to be reduced into another long ſquare, whoſe breadth ſhall be equal to the line XZ. Firſt continue the line AB towards L, and the line AD towards G, then ſet the line XZ from D to G, and draw out the line GC to cut the ground-line AB in L, ſo ſhall BL be the length of the long ſquare inquired, with which length and the given breadth XZ, make the long ſquare EFBL, which ſhall be equal to the long ſquare given ABCD, which was required.



PROBL. VI.

To reduce a Triangle into a Geometrical Square.

LEt ABC be a Triangle given to be reduced into a ſquare. Firſt, let the perpendicular DB be extended upwards towards I, then ſet the length of the perpendicular BD from D to P, next ſet half the Baſe from D towards C, which endeth in G, then

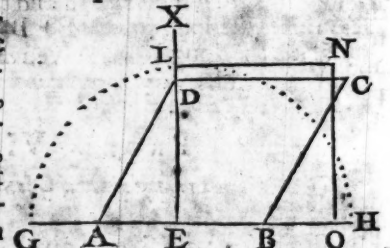


then take hal the line P G, which is in H, and with that half, *viz.* H P, or H G, describe the Semicircle, which cutteth the perpendicular in I, so will D I be the side of a square whereby the square D I M K is equal to the Triangle A B C, which was required.

PROBL. VII.

To reduce a Rhombus into a Geometrical Square.

LEt A B C D be a Rhombus given, to be reduced into a Geometrical Square. First, because every Rhombus is equal to the long square, whose length and breadth are equal to one of its sides and the Parellel distance, therefore draw the perpendicular D E, which is the Parallel distance, and extend it upwards towards X, then take the perpendicular and set it from E to G, and also set the side A B from E to H, then with half the distance of G H, describe the Semicircle, which cutteth the perpendicular in L, so is the perpendicular E L the side



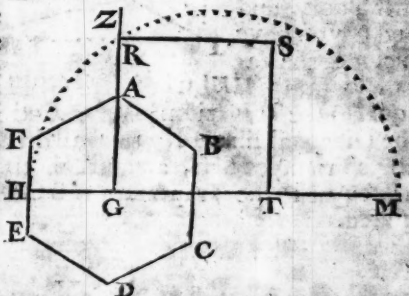
ſide of the ſquare, and conſequently the ſquare LNOE is equal to the Rhombus ABCD, as was required.

The like for the Rhomboides.

PROBL. VIII.

To reduce an æquiangled Poligon into a Geometrical Square.

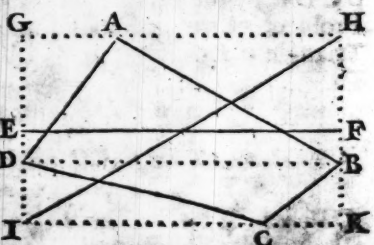
LEt ABCDEF be a Hexagon given, to be reduced into a ſquare. Firſt, according to the 18. Probl. of the third Book, every regulat Poligon is equal to that Oblong, or long ſquare, whoſe length and breadth are equal to half the Perimeter, and the perpendicular drawn from the center to one of the oppoſite ſides, therefore ſet half the Perimeter of this Hexagon, from G to M, and raiſe the perpendicular G A from G towards Z, then on *A M*, deſcribe the Semicircle *H R M*, which cutteth the perpendicular in R, ſo will G R be the ſide of the ſquare, and conſequently the ſquare G R S T will be equal to the Hexagon A B C D E F, as was required.



PROBL. IX.

To reduce a Trapezium given, into a Right-Angled Parallelogram, or into a Right Angled Triangle.

SUppoſe ABCD be a Trapezium to be reduced into a Parellelogram, or into a Right angled Triangle. Firſt, draw the Diagonal-line BD, then by the points A and C, draw the lines *GH* and IK parallel to the Diagonal line DB, by the firſt Problem of the firſt Book, and and ſo you have included the Parallelogram *GHKI*, whoſe half GEFH, or EIKF is equal to the Trapezium given. And if you draw the Diagonal-line HI, you ſhall deſcribe the right angle Triangles GHI, and IKH, either of which are equal to the Trapezium ABCD, as was required.

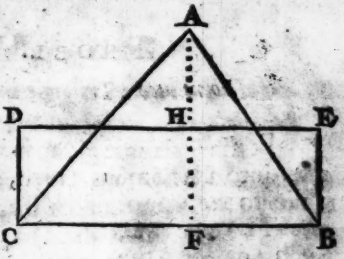


PROBL. X.

To reduce a Triangle given into a right angled Parallelogram.

LEt ABC be a triangle given to be reduced into a Parallelogram. Firſt, draw the Perpendicular AF, by the 3. Problem of the firſt Book, which divide into

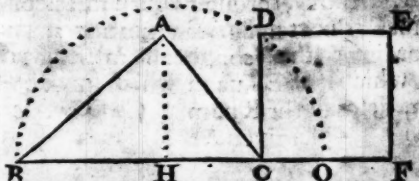
into two equal parts at H, and take one half thereof for the breadth, and the whole Base B C for the length, with which length and breadth, describe the Parallelogram, B C D E by the 13. Problem of the first Book, which is equal to the Triangle *A B C*.



PROBL. XI.

To reduce a Triangle into a Geometrical Square.

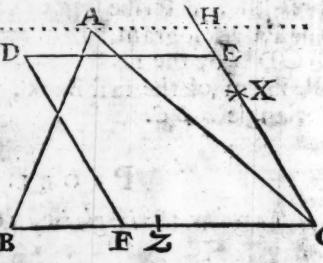
SUppose A B C be the Triangle given to be reduced into a Geometrical square. First, by the second Problem, seek a mean proportional line between the Base B C, and half the perpendicular AH (*viz.* C O) which let be C D, by which you may by the 12. Problem of the first Book, describe the square CDEF, which shall be equal to the given Triangle ABC, as was required.



PROBL. XII.

To reduce a Triangle into a Rhombus.

LEt the Triangle given be ABC, to be reduced into a Rhombus. First, draw the line AH parallel to the Base of the Triangle BC, then divide the said Base into two equal parts in the point Z, on which point set one foot of the Compasses, & with the distance ZB, or ZC, strike an Arch towards X, then with the same distance, setting one foot in C, with the other cross the former Arch in X, through which intersection draw the line CH, next finde out a mean proportional line (according to the second Problem) between CX and XH, which is CE, upon which line, by the Problem, describe the Rhombus CEDF, which is equal to the Triangle given ABC, as was required.

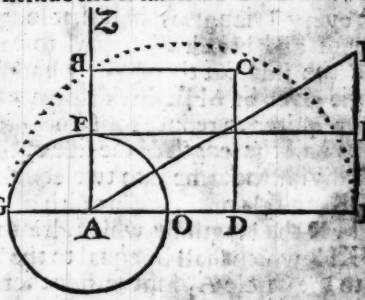


PROBL.

PROBL. XIII.

To reduce a Circle into a Geometrical Square.

LEt A be the Circle given to be reduced into a ſquare. Continue the Diameter GAO towards H, then on the center A erect the perpendicular AZ, then ſet three times the Semidiameter of the Circle, and ſ G part thereof, from A to H, and on the line GH deſcribe the Semicircle G B H, which cutteth the perpendicular in B, hence A B is the ſide of a ſquare required, and conſequently the ſquare ABCD is equal to the Circle A.



PROBL. XIV.

To reduce a Circle into a right-angled Triangle.

AGain, the Circle may be reduced into a Right angled Triangle, for by the 1. of the 11. of Elem. every Circle is equal to that right angled Triangle, of whoſe containing ſides, the one is equal to half the Periphery, and the other to the Diameter, and ſeeing now the line AH is equal to half the circumference, and the line HE is equal to the

the Diameter of the Circle GO, therefore the Rectangled Triangle AHE, is equal to the Circle A, as was required.

PROBL. XV.

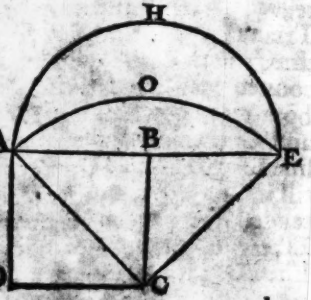
To reduce a Triangle, or a Circle, into a long Square.

ACcording to the 10. Problem of the third Book, every Triangle is half that long ſquare, whoſe length and breadth is equal to the perpendicular and the ſide cut thereby. Therefore let the Triangle given be AHE in the former Diagram, and it is required to reduce the ſame into a long ſquare. Take half the length of the ſide of the Triangle HE, and divide the ſame into two equal parts at K, then is HK equal to AF, the breadth of the long ſquare, and EK the length, by which, draw the long ſquare AFKH, which ſhall be equal to the Triangle AHE, or to the Circle A, for the ſide thereof AH is alſo equal to the circumference, and the breadth thereof AF to the Semidiameter.

PROBL. XVI.

To reduce a Square into a figure of a Lunular form.

LEt ABCD be a ſquare given to be reduced into a Lunula. Firſt, draw the Diagonal AC, and on the end thereof C, raiſe the perpendicular CE, by the 4. Problem of the 1. Book, whoſe length CE make equal to CA, D



then

then continue the ſide AB to E, and on the point B, with the diſtance B A equal to B E, deſcribe the Semicircle AHE, and alſo on the point C, with the diſtance CA equal to CE deſcribe the Archline AOE, which two lines will include the Lunula *AOEH*, equal to the given ſquare ABCD, as was required.

PROBL. XVII.

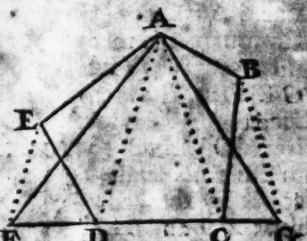
To reduce a Lunula into a Square.

LEt the Lunula be AHEO, which is to be reduced into a ſquare. Firſt, draw the line AE, then on the one half thereof AB, make the ſquare ABCD, which will be equal to Lunula AHEO, as was required.

PROBL. XVIII.

To reduce an irregular figure into a Triangle.

LEt ABCDE be the figure of ſome irregular Field, and it is required from the angle A to reduce the ſame into a Triangle. Firſt, continue the ſide DC of convenient length both ways towards F and G, then draw the line EF parallel to AD, till it interſect the extended line CD in F. Likewiſe, draw the line BG, parallel to AC, cutting the extended line in

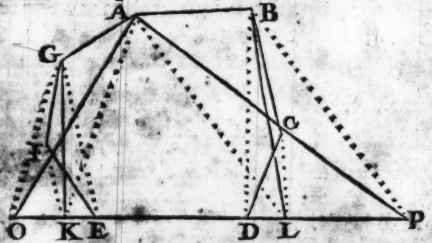


in G, then from the angle A, draw the lines AF and AG, so shall you have the Triangle AFG equal to the irregular Pentagon A B C D E, which was required.

PROBL. XIX.

To reduce an irregular Multangled figure, into a Triangle.

Suppose *ABCDEFG* be an irregular Plot given, to be reduced into a Triangle. First, draw the line GE, and parallel thereto the line FK, then

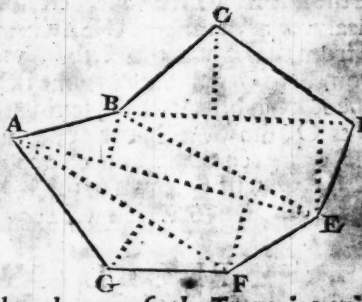


from G, draw the line GK; next from B draw the line BD, and parallel thereto the line CL, then from B, extend the line to L, so is the Plot of seven sides reduced to five, namely to the figure ABLKGA. Secondly, according to the last Problem, extend the side KL towards O and P, then draw the line GO parallel to *AK*, till it cross the line KL in O. Also draw BP parallel to the line *AL*, till it cross the extended side KL in P. Lastly, draw the lines *AO* and *AP*, so shall you include the Triangle *AOP* equal to the irregular Heptagon *ABCDEFG*, which was required.

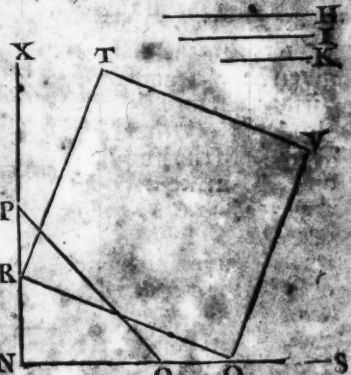
PROBL.

PROBL. XX.

To reduce an irregular Plot into a Geometrical Square.



LEt *ABCDEFG* be an irregular figure given, to be reduced into a ſquare. Firſt, draw the lines BE and *AF*, ſo will the figure be divided into two Trapezias and one Triangle, then croſs the Trapezias with the two Diagonals BD and *AE*, and let fall perpendiculars thereon from the angles C, E, B, and F, and alſo from G, to the Baſe of the Triangle, then, as before is ſhewed, in the 2. Problem of this Book, ſeek out a mean proportional between halt the Baſe BD, and the two perpendiculars thereon falling, which is equal to the line H. In like manner ſeek out a mean



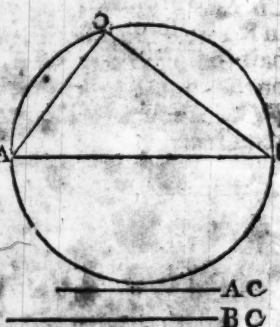
pro-

proportional between half the Base *A E*, and the two perpendiculars thereon falling, which will (in this example) be equal to the line I, so also finde out the mean proportional between half the Base of the Triangle *A F* and its perpendicular, which let be the line K, which done, describe a right angle at pleasure, as the angle XNS, wherein place the line H from the right angle N, to P, and also the line I, from N to Q and draw the line PQ. *Also* place the line K from N to R, then setting the line PQ from N to O, draw the line R O, which is the side of the square required, and consequently the square R T V O will be equal to the foregoing irregular figure *ABCDEFG*, which was required.

PROBL. XXI.

To make a Circle that shall be equal to any two Circles given.

LEt the two Diameters of the Circles given be *A C* and *B C*. First, therefore, by the Problem of the first Book, with the lines *A C* and B C make a right angle, as *A C B*, then draw the subtending line *A B*, on which line describe the circle *ABC*, which shall be equal to the two Circles, whose Diameters were equal to the lines *AC* and BC, as was required.

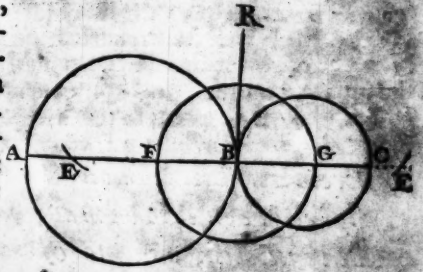


PROBL.

PROBL. XXII.

To subtract a lesser Circle out of a greater, and to produce the remainer in a third Circle.

LEt the two Circles given be *AB* and BC, and it is required to subtract the Circle BC out of the Circle *AB*, and to produce the remainer in a third Circle. Take the Diameter of the lesser Circle *BC*, & raise it perpendicularly on the point *B* to *R*, then take the Diameter of the greater Circle *AB*. and placing one foot of the Compasses in R, with the other strike the arch at E, then at half the distance of *BE*, describe the Circle F G, on the point *B*, so will the two lesser Circles FG and *BC*, be equal to the greater Circle *AB*, as was required.



The End of the Fourth Book.

The ART of SURVEYING.

The Fifth Book.

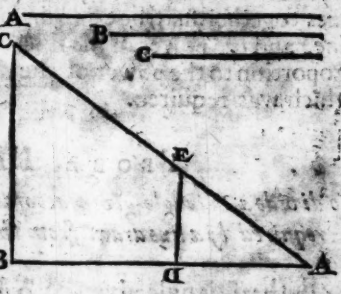
Wherein is ſhewed how to divide any figure given into as many parts as ſhall be required, and to cut off from the ſame any quantity whatſoever, being of ſingular uſe in Surveying and dividing Lands.

PROBL. I.

To divide a right line given according to any proportion required.

A Right line being given, as the line *A*, it is required to divide the ſame into two ſuch parts, which ſhall have ſuch proportion the one to the other, as the line *B* hath to the line C. Firſt, make an angle of any quantity, as *CAB*, and let the ſide *AB*

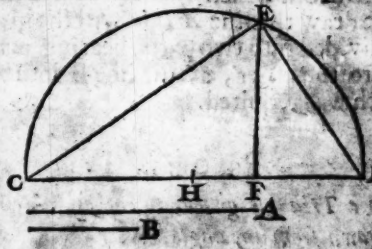
A B be equal to the given line *A*, then place the line C from *A* to E, and the line *B* from E, to C, and draw the line *CB*. Lastly, from the point E draw the line E D parallel to *CB*, cutting the line *AB* in D, so shall the greater Segment *BD* bear the same proportion to the lesser *D A*, as the line *B* hath to the line C.



Probl. II.

To divide a righe line in power according to any proportion given.

First, draw the line C D equal to the sum of *A* and B, then divide the said line in the point F, in proportion as A to B, and upon the said given line C D describe the Semicircle C E D, and on the point F raise the perpendicular F E, cutting the Semicircle in E, from which point, draw the lines EC and ED, which two

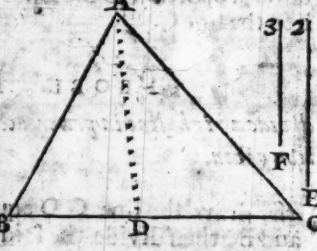


lines together, shall be equal in power to the given line, and the power of the line E C shall be in such proportion to the power of the line E D, as *A* to *B*, which was required.

PROBL. III.

To divide a Triangle given according to any Proportion required, by a line drawn from the angle assigned.

LEt the Triangle given be A B C, and the angle assigned *A*, from whence it is required to divide the same into two parts bearing such proportion the one to the other, as the line E doth to the line F. Therefore by the first Problem divide the Base B C as E to F, in the point D, from which point draw the line *A D*, so will the given Triangle be divided into two parts, bearing porportion the one to the other, as the line E doth to the line F, which was required.

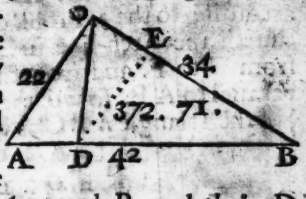


PROBL. IV.

From a Triangle given, to cut off any parts by a line drawn from any angle thereof

LEt the Triangle A B C contain 372. ½ *fere*, and the side *A B* 42, it is required to cut off 50. parts with

with a line iſſuing from the angle C, to cut the line AB. To effect this, ſay by the rule of proportion, if the area of the Triangle 372.71. give the whole Baſe AB 42, how much of that Baſe in the ſame parallel ſhall 90 to be cut off require The anſwer will be 10.14, which ſet from *A* towards B. endeth in D, then draw the line C D, and the Triangle A C D will contain 90, as was required.

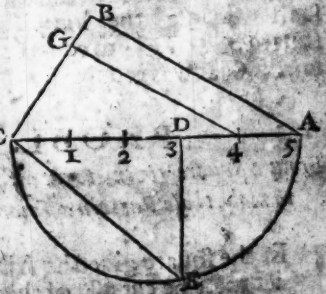


Or elſe, double the parts to be cut off, and they make 180, which divide by the length of *A C* 22, the Quotient is 8.182, at which diſtance draw the line D E parallel to A C, which ſhall include the Triangle *A C D* to contain 90. as before.

PROBL. V.

To divide a Triangle according to any proportion given by a line drawn parallel to any of the ſides aſſigned.

LEt A B C be a Triangle given, and it is required to cut off $\frac{3}{5}$ by a line Parallel to AB. Firſt on the line A C deſcribe the Semicircle A E C, whoſe Semidiameter C A divide into five equal parts, accord-

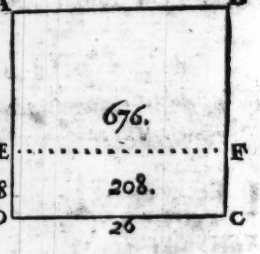


ing to the greater term, and upon three of those parts (the lesser term) erect the perpendicular D E, according to the 3. Probl. of the first Book, which cutteth the Arch-line in E, then let the line C E from C to F, and from thence draw the line F G parallel to A B, so will the Triangle C G F contain ⅜ of the Triangle A B C, as was required.

PROBL. VI.

To divide a square into two parts according to any proportion assigned, by a line drawn parallel to one of the sides.

LEt the square given be ABCD, containing 676, and it is required to cut off 208, with a line parallel to C D, to be laid out next unto the same; first divide 208, by the side of the square 26, and the Quotient is 8, which distance set from C to F, and from D to E, then draw the line E F, which shall include the long square *C D E F*, to contain 208, as was required.



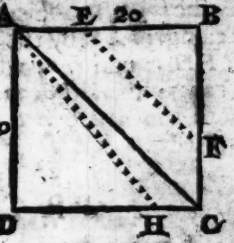
PROBL. VII.

From a Square given, to cut off any parts assigned and to make those Parts in a Triangle.

LEt the square given be ABCD, from the which let there be cut off ⅜ of the area, by a line Paral-

lel

lel to the Diagonal AC. Therefore in the Triangle ABC, ſuppoſe it be required to divide it into two equal parts with a parallel-line to AC, which is found by the fifth Problem of this Book, to be the Triangle *EBF*, which is the half of the Triangle *ABC*.

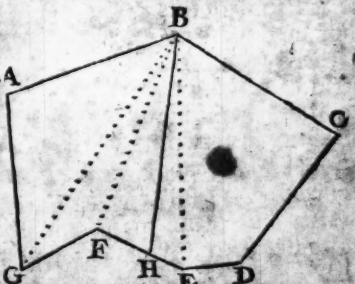


But ſuppoſe it be required to cut off 145, by a line iſſuing from A to *DC*; firſt therefore, becauſe the whole ſquare contains 400, the Triangle *ACD* is 200, from which you may cut off 145, by the fourth Problem of this Book, ſo ſhall the Triangle *DAH* contain 145, which is the thing required.

PROBL. VIII.

From an irregular figure given, to cut off any parts required.

LEt the figure given be *ABCDEFG*, and it is required to cut off 420, with a line drawn from B to cut the oppoſite ſide. Firſt meaſure the Trapezium *ABFG*, which contains 324, then meaſure the Triangle *BEF*, and you ſhall finde

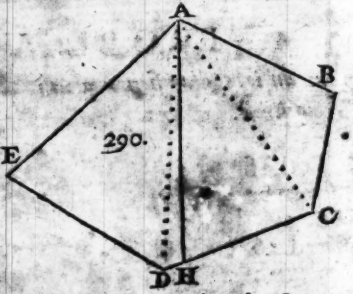


it 135, which added to the Trapezium maketh 459, which exceedeth the parts to be cut off by 39. Then, by the fourth Problem, cut off the said 39, from the Triangle *BEF*, by the line BH, so will the Triangle *BFH* contain 96, which added to the area of the Trapezium *ABFG*, 324, maketh 420, and so much doth the figure *ABHFG* contain, as was required.

PROBL. IX.

To divide a figure given into any equall parts required.

LEt *ABCDE* be a figure given, to be divided into two equal parts. The area of the whole figure is 705, whose half is 352. 50, wherefore the triangle *ADE* wanteth thereof 62. 50, which take from the triangle *ACD* by the 4. Probl. of this Book, and there remaineth the Triangle ADH, so will the line AH divide the figure into two equal parts, whereby the figure ABCH is equal to the figure AEDH, as was required.



After the same manner you may divide any figure into as many parts as you please, and from what point you please, whether it be from a side, or an angle, as with a little practice you may soon per-

perceive; and therefore I shall not over-burden the Book with needless curiosities, but shall now hasten to the more practical part of *Survey*: yet if a fitter occasion present it self, we may probably hereafter, inlarge our present conceptions upon this subject.

The end of the Fifth Book.

The ART of SURVEYING.

The Sixth Book.

Wherein is shewed how to take the exact Plot of all manner of Grounds whatsoever, after several ways, and how to cast up the just quantity and content thereof in Perches and Acres, and to divide the same into as many parts as shall be required: together with Directions to inclose and take in a Lordship, that lies in Common, or in open Feild, and to draw a perfect Map thereof.

CHAP. I.

A Description of the Plain Table, with its several parts and composition, &c.

AMongst the manifold Instruments which have hitherto been invented for the exact and speedy Plotting and measuring of all kindes of Land, there is none so plain and perspicuous in use and practice, as this Instrument, and therefore it aptly receiveth

ceiveth the name and appellation of the *Plain-Table*: And albeit this Inſtrument (as well as any other) may be ſlighted and abuſed by the ignorance of ſome common Mechanicks, and other illiterate pretenders to the Art, that ſcarce ever underſtood what the Mathematicks were, yet why ſhould it deter any Artiſt from the uſe and practice thereof, ſeeing we may not onely, with more eaſe and exactneſs, and with leſs fear of errors and miſtakes, attain our deſired aim far better thereby, then can (poſſibly) be done with any other Inſtrument whatſoever, as is well known to all Practical Surveyors, who are acquainted both with the uſe of this and the reſt. And yet I cannot but highly commend the *Theodolite*, *Circumferenter*, and the *Peractor*, as Inſtruments very uſeful upon ſome occaſions, neither dare I reject, as uſeleſs, either the *Topographical Inſtrument*, and *Croſs-ſtaffe* of Mr. *Diggs*, the *Familiar Staffe* of Mr. *John Blagrave*, the *Geodetical-Staffe*, and *Topographical-Glaſs* of Mr. *Arthur Hopton*, the *Sector*, *Croſs-Staffe*, and the *Pandoron* of my late worthy friend Mr. *George Atwell*, or any other commodious invention that hath hitherto been wittily deviſed, for the exact Plotting, and ſpeedy menſuration of all manner of ſuperficies, as Land, and the like. But in regard the Authors themſelves have in their own Works (to their exceeding commendation) deſcribed both the making and uſe of the ſaid Inſtruments, I ſhould here but tire my Readers to reiterate what they have already ſhewed elſewhere, and ſo make theſe few lines ſwell beyond their intended bounds; and beſides Mr. *Aaron Rathborne*, in the beginning of his third Book, and my loving friend,

Mr.

Mr. *William Leybourn* in the first five Chapters of his second Book, have very well saved me that labour; where they have excellently treated, both of the composition and use of the most material and commodious Instruments now in being, to which the *Semicircle* may be added as being inferior to none of the forementioned. Wherefore I shall now come to speak of the composition of the *Plain Table*, which indeed is the Instrument, of whose use alone we shall afterwards treat of.

This Instrument (commonly known by the name of the Geometrical, or Plain Table) is in the fashion of a Parallelogram, or long square, containing in length about 14 inches and a half, and in breadth 11 inches; and were it not for warping, it might be made of one board, but for avoiding that, and for the conveniency of carriage, the best way (as they are usually made) is to have it of three boards in breadth, with a ledge at each end for holding them together, and making the Table of due length; whereunto belongeth a joynted frame, that when the five boards are set together, and a sheet of Paper put thereon, the frame may binde the same so fast and smooth upon the Table, that when you come into the field, you may neatly describe a Plot of your Land, Wood-ground, or other Inclosure, upon the same, as shall be afterwards shewed.

Again, let the sides of the frame of the Table be divided into equal parts, or scales, for the drawing of parallel lines when you shift your paper, and put on another sheet. And on the other side your frame, it would be very necessary to have projected upon it, the 360 degrees of the Circle from a center

centre made about the middle of the Table, which will be of excellent uſe in wet and ſtormy-weather (as my worthy friend Mr. *Leybourn* well adviſeth) when as you cannot keep a ſheet of paper upon the Table.

To this Inſtrument there belongeth a Rule, or Index of Braſs, which muſt contain in length at leaſt 16 inches, in breadth about 2 inches, and in thickneſs ; of an inch. Upon this Index are to be placed two ſights, both of one length, the one having a ſlit below, and a third above, and the other a ſlit above and a third below, ſerving to look forward and backward, when you are upon plotting; and theſe ſights muſt be ſo placed upon the Ruler, either with Screws, or ſquare Morteſſes, that both the ſights may be equidiſtant from the fiduciall edge of the Ruler. Moreover upon the face, or upper part of this Ruler, are ſeveral Scales of equal diviſions, as of 10. 12. 16. 20. 24. and 32 parts in an inch; ſerving to lay down the Plot of a Field according to what proportion ſhall be thought moſt convenient for that purpoſe. There alſo belongeth to this Inſtrument a Box and a Needle, which is to be placed on the ſide of the Table, with two Screws; and in the bottom of the Box is placed a Chard, divided into 360 deg. which is covered over with cleer Glaſs.

Laſtly, On the backſide of the Table is a Socket of Braſs faſtned to the Table with three Screws, into which Socket muſt be put the head of the three legged Staffe, which for portability, is uſually joynted in the middle.

Ad-

THey that desire this Instrument, may have it (and all the parts thereof) ready made, after the best fashion, at Mr. Anthony Thompsons House in Hosier-lane neer Smithfield: And also by Mr. Walter Hayes at the signe of the Cross Daggers, neer the Popes head Tavern in Morefields London, Who also maketh all kinde of Mathematical Instruments whatsoever, both in Brass, Wood, and Silver.

Chap. II.

The use of the Scale and Protractor.

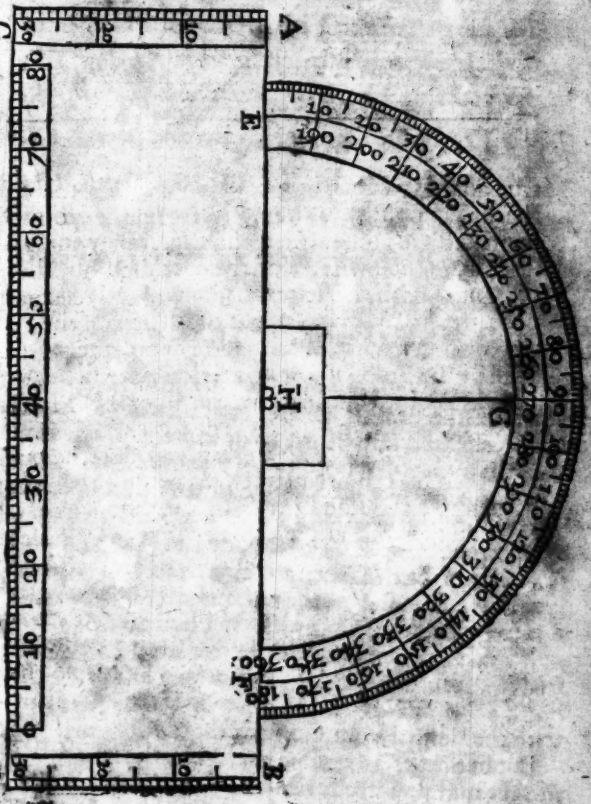
UPon the Brass Rule are several Scales of equal parts, as I said before, as of 10. 12. 16. 24. & 32 parts in an inch, whose use are principally to lay down, upon Paper, the length of any line taken in the field in Perches.

Upon the same Rule (or upon the Pocket Rule) is a Scale of Chords, which serveth to protract and lay down upon Paper, the just quantity of an angle, for if you open the Compasses to 60 degrees thereof, and with that extent describe an arch; you may therein set off what deg. and min. you please, by taking the just extention thereof from the Scale, with the help of your Compasses.

But in the practise of *Survey*, when the weather is moist, and you are forced to take the quantity of angles by the degrees on the frame of the Table, or by a Semicircle, you may speedily perform the work thereof by the Protractor.

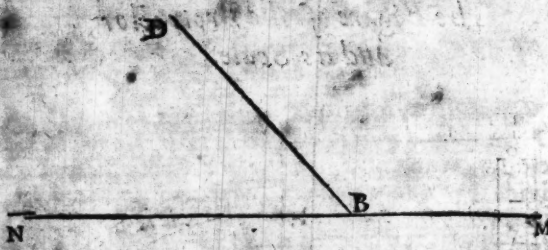
The

The Figure of the Protractor, and its Scale.



Sup-

Suppose it be required to lay down on Paper the



true quantity of an angle of 50 degrees taken in the field upon the line *MN* from the point B, upon which point place the center of your Protractor, in such wise, that the Meridian line thereof, noted with the letters A H B may lye exactly upon the line MBN, so that the center of the Protractor noted with H, lye exactly upon the point B, then in the limb of the Semicircle at 50. degrees, note the point D, and draw the line B D, so shall the angle D B *M* contain 50. degrees.

But if *MBD* were an angle given, and the quantity thereof required, then place the Protractor, as before, and the Limbe of the Semicircle will tell you that the angle *D B M* is 50. degrees, and (laying the Meridian line of the Protractor upon the line DB) it will give you the angle NBD to be 130. degrees, it being the Complement of the angle DBM to the Semicircle 180. degrees. But these things you will find so easie, that I need not insist further thereon.

CHAP.

CHAP. III.

Of the Chain, with the Diviſion, and uſe thereof.

SOme Surveyors ſtill work by a Chain of 16 parts in a Perch, others (as *Mr. Gunter* in his deſcription and uſe of the Sector, Croſs-Staff, &c.) divide the whole Chain of 4 perches into 100 links, but *Mr. Aaron Rathborne* in his Surveyor printed *Anno* 1616. makes diviſion of every perch into 100 parts, that is to ſay, firſt he divides each perch into 10 parts, called Primes, each Prime whereof is again ſub-divided into 10 parts more, which he calls Seconds; and this is commonly called the Decimal-Chain. But the Chains that I have uſually made for my ſelf, contain in each Pole 20 links, ſo that in the uſe thereof I apply it to Decimal operations, wherein to avoid prolixity, I account two links to be one Prime, and one link to be five Seconds, and yet notwithſtanding in Geodæſie, or Land-meaſure (unleſs it be out of curioſity) it is needleſs to go neerer then a link of your Chain. But ſeeing my intent in this Chapter is onely to ſhew you how you may ſpeedily multiply the ſeveral fractions of your Chain together, as if they were whole numbers, I will firſt ſhew how to effect it by the Decimal-Chain invented by *Mr. Rathborne*, and then afterwards by my own of 20 links in a perch.

Firſt therefore, Suppoſe I ſhould meaſure a peice of Land (lying in the form of an Oblong, as moſt Lands in common Fields do) and finde the ſame to contain in length 42 perches, 6 primes, and 4. Seconds,

conds, in breadth 12 perches, 8 primes, and 4 Seconds, therefore to effect my desire, I place my numbers in all respects, as is usual done in whole numbers, and over every fraction of the multiplycand, place a prick or point, and at the end of the multiplyer place also as many points as there are fractions in that nnmber, then multiply your two sums together, as though they were whole numbers, and the product will tell you how many perches and parts of a perch, are in that parcel of Land, onely you must observe that so many pricks as you made, so many figures must you cut off from your product to the right hand, so will you have the true value of your Land in Perches and parts of a Perch, as the example following will more cleerly demonstrate.

An example of a peece of ground, whose length is 42 Perches, 6 Pri. 4 Sec. the breadth 12. Perches, 8 Pri. 4 Sec. which are thus multiplyed together, as if they were whole numbers.

Here you see there are two fractions in the multiplicand, which are noted with two pricks over head, and as many in the multiplyer, as they are marked towards the right hand, so that, as you see, after the operation is performed, because I have four fractions, I must strike off with a dash of my Pen, the four last figures of the product towards the right hand, and then will the product stand thus 547. 4976. which intimate, that there are contained in this piece of Land 547, whole Perches, and $\frac{4976}{10000}$ parts of a Perch, which is neer upon half a Perch.

	4264
	1284
	17056
	34112
	8528
	4264
	5471497 6

But

But becauſe a Chain of 20. links in a Perch is more ready, and altogether as exact as the former, I will alſo ſhew you in one operation how you may readily and truly work thereby. Therefore ſuppoſe a peece of land be in length 36 perches, and 16. links, and in breadth 3. perches and 2. links, and becauſe I have 20. links in a Perch, therefore that I may performe the operation in a decimall way, I account but half the number of my links, and then the ſums will ſtand thus.

Now multiplying the 2. ſumms together, as before was done, and marking the fraction, I finde the ſum of the multiplication to be 11408. and in regard of the two fractions, I ſtrike off the two laſt figures of my Product towards the right hand, and then the ſum will ſtand on this wiſe, 114.08, which is 114. perches, and one 8. part of a 100. and ſo much is the ſaid peece of land, according to Statute meaſure.

	368
	31.
	368
	1104
	11408.

But if the land had been 36. perches, and 9. links in length, and 3 perches, and 3. links in breadth, then you are to place the numbers thus.

Multiplying the two ſumms together, and from the Product, cut off the four laſt figures becauſe of the four fractions, and then the ſum will ſtand on this wiſe 114.8175, ſo that the land contains 114. perches, and above three parts of a Perch.

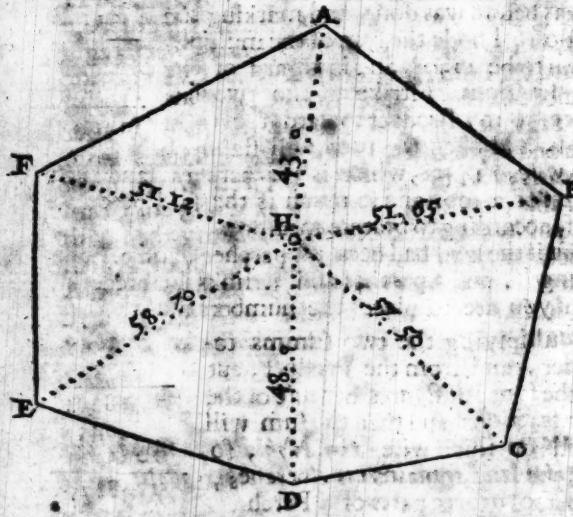
	3645
	315.
	18225
	3645
	10935
	1148175.

CHAP.

CHAP. IV

To take the true Plot of a Field at one Station taken in any part thereof, from whence you may see all the angles, or corners, of the same.

Suppose A B C D E F be a Field to be measured. First cause white Papers, or other visible marks, to be set up in every corner, or angle of the same,



then make choice of some convenient place therein, from whence you may best view all the angles thereof, in which place, as at H, plant your Table (covered

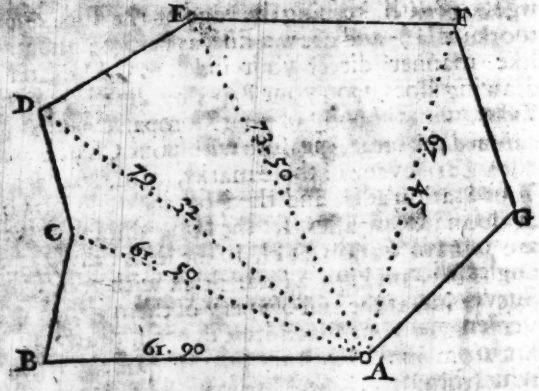
(coveted with a sheet of clean paper) and so fasten it with the Screw-pin, that the Table stir not, till your worke be finished. Then placing your Index upon the Table, lay the Fiduciall line there of upon the point H, representing the place of your Station, and then direct your sight to A, and draw a line with your Compass point by the side of the Index upon the Paper, which done, direct your sight to B (still keeping the edge of the Index upon the point H) and draw a line, as before; and so in like manner direct your index to C, D, E, and F, drawing lines upon your Paper by the edge of the Index, with the point of your Compass, and having finished the same, measure with your Chaine, the distance of every of those marks, from the place of your Station at H, and then by the help of your Scale and Compasses, set the same distances from the point of station, at H, in the lines drawn upon the Table, making a small prick with your Compass point, at the end of every of them, then with the point of your Black-lead Pencell, draw a small line from one point to another, as namely from A to B, from B to C, and from C to D, &c. so shall you have upon the Table, the exact Plot of your Feild.

CHAP. V.

To take the Plot of any Feild at one station in any one angle thereof, from whence all the other angles may be seen.

FIrst, as before, set up Whites in every corner of the Feild, as at B C D E F and G, then make choice of the most convenient angle therein,

from whence you may best veiw all the rest, as A, which shall represent your place of station, & having fixed your Table there, as before is taught, apply the Index to the point A, and direct the sights to B, then draw the line A B upon the paper, and with your Chain measure the length thereof, and set it down, by help of your *Scale* from A to B.



Then secondly from the said point A, turn your sights to C, your second mark, and then draw with the one point of your Compasses, upon the paper, the line A C, measuring the distance, and setting down the length by the same scale, as you was before taught.

In like manner direct your sights to D, E, F and G, and drawing lines upon the paper, measure with your Chaine, the distance of each of the same angles from your station point at A, where your Table is planted, then with your Compasses, take from

from your ſcale, the ſaid diſtances reſpectively, and ſet them down from the point A, upon the ſeverall lines, AD, AE, AF, AG, ſo ſhall you have upon the paper, the points A B C D E F, by which marks, you may, by the help of a Black-lead-pencell, finely pointed, deſcribe the lines AB, BC, CD, DE, EF, FG, GA, which will exactly repreſent the juſt figure of your Feild upon the Table, which will be greater, or leſſer, according to the Scale you worke by.

CHAP. VI.

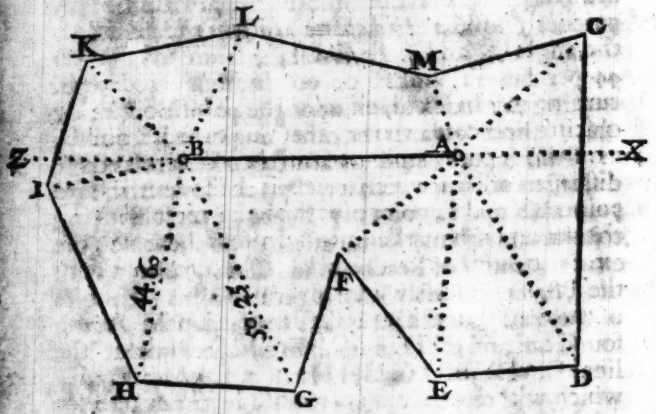
To take the Plot of a Field at two Stations when as all the angles thereof cannot be ſeen at one.

IT oftentimes hapneth, either through hills, or the Spaciouſneſs of the ground, that you cannot from any one place of the Field, ſee all the corners and angles thereof; in which caſe, it behoveth the Surveyor to make choice of two of the moſt convenient places within the ſame; ſo that here you are to performe that by the help of two Stations, which before was effected at one.

Suppoſe therefore that the figure noted with the letters C D E F G H I K L M, be a Field to be plotted, which lyeth ſo, that from no one place all the angles thereof can be ſeen, therefore I make choice of two places within the ſame for my two Stations, as A and B, where I can conveniently view all the angles. And firſt I plant my Table in A, from whence I can ſee the angles M C D E F, then placeing the edge of my Index (after the Table is fixed) upon the point A, I direct my ſights ſeverally to all the angles within my view, as to M C D E F,

drawing lines as before is directed in the preceding Chapters, which done, I measure every of them with my Chain, and note them down from my Scale, as formerly I shewed.

Then (my Table remaining fixed) I view the other parts of the Feild, and make choice of the point B for the place of my second Station, because from thence I can see all the other angles of the Feild, then setting up a white, or other Beacon there, I go back to my first station at A, (where my Table



stands fixed, as I left it) upon which point I move my Index, till through the sights thereof, I espie the mark at B, which done, I strike a line by the fiducial edge of the Index, with my compass point, extending it quite over the Table, as is represented by the line ZX, which being thus performed, I measure the

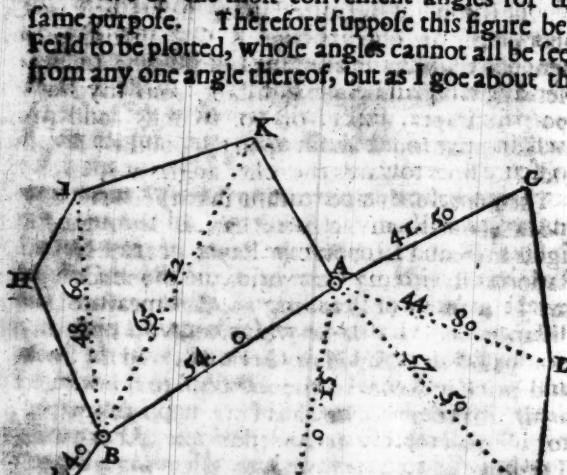
the ſtationary diſtance AB, finding it 53. perches 5. links (or 25. ſet.) which I ſet down from A to B, the place of my ſecond ſtation by the help of my Scale and Compaſſes, in ſuch ſort as I have formerly ſhewed.

Secondly I plant my Table upon the point B, and laying the edge of my Index upon the line Z X, I turne the Table about, till through the ſights, I behold my firſt ſtation at A, then I ſcrew the Table faſt to the ſtaff: afterwards moving my Index upon the point B, I direct the ſights firſt to G, drawing the obſcure line B G, containing 50. perches 5. links, then againe I direct the Index to the angle H, and finde it diſtant from my ſtation 44. perches 12. links, or 60. ſeconds, and thus, turning my Index about upon the point B, I draw obſcure lines towards the other angles at I, K and L, as I did before, and meaſuring their reſpective diſtances with my chain, I prick down the ſaid points I, K and L, upon my Paper, ever obſerving to take off with my Compaſſes, upon the ſcale, the exact quantity of Perches, and Parts meaſured with the Chaine. Laſtly, the ſeverall points or angles of the Feild at C D E F G H I K L and M, being found out and marked upon my Paper, I draw the lines CD, DE, EF, FG, GH, HI, IK, KL, LM, and MC, which will repreſent upon the Table, the exact Plot of the Feild to be meaſured.

CHAP. VII.

To take the Plot of a Field from two angles, when as all the said Feild cannot be seen from one.

THis work differs little from the former, for whereas there you made choice of two places within the Field, for your two stations, from whence you might view all the angles; so here you must two of the most convenient angles for the same purpose. Therefore suppose this figure be a Feild to be plotted, whose angles cannot all be seen from any one angle thereof, but as I goe about the



Field to view the same, I immediately see, that the angles A and B, are the most fit and convenient for

for my purpose, being seated upon higher ground then any of the other, wherefore setting up a Beacon in the angle B, I repair to A, where I plant my Table, & fasten it with the Screw-pin, then upon the point A, I apply the fiduciall edge of my index, and direct the sights thereof to C, and measuring the said distance with my Chain 41 ˢ 50. I prick it down upon the paper from A to C, according to its extention upon the Scale, and I make a prick with my Compass point, which will represent the point C. This done, I turn my index towards D, till through the the sights thereof *I* espie my Beacon there placed, then measureing the distance 44 ˢ 08. *I* set it down in the said line, and make a prick upon the Paper, which will represent the point D. In like manner I deale with the angles at E and F.

Then (my Table remaining fixed) I turne my Index about upon the point A, till through the sights thereof I discover the point of my second station at B, and see the Thrid cut the middle of my Beacon there standing, then I measure the distance, finding it 54 ˢ 0, which known, I open my Compasses to 54. upon my Scale of 32. in the inch, and prick it down in the line A B to B, where I again make a marke thus (⊙) upon my paper, for the place of my second station. Afterwards, I remove my Table from A to B (leaving a Beacon at A, when I came from thence) and placeing my Index upon the stationary line B A, I turne the Table about, till at length I see (through the sights thereof) the Beacon I set up at the place of my first station, then fixing my Table, as formerly I shewed, I direct my sights to the severall marks, at G, H, I, and

and K, and ſtrike lines upon the Paper towards them; and meaſuring particularly their diſtance, I ſet it (by the help of my ſcale) upon the Paper, from B to G H I and K, where I make ſmall pricks with my Compaſſe point: and then drawing lines ſucceſſively about the Perimeter, from point to point, you ſhall have the exact ſimmetry and proportion of your Field, as it is repreſented in the former Figure by the lines AC, CD, DE, EF, FG, GH, HI, IK, and KA.

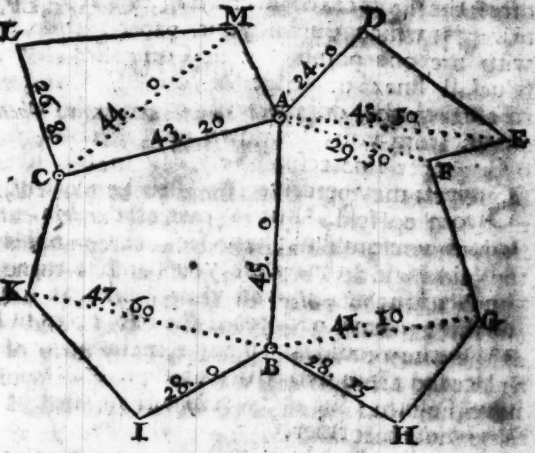
CHAP. VIII.

To take the Plot of a Field from three Angles when all the angles cannot be ſeene from two.

Suppoſe this Figure be a Field to be plotted, and from no two angles thereof, all the reſt can be ſeen, wherefore I make choice of three angles, as A, B, and C, and begining firſt at B, I turne my Index upon that point, directing it to I, H and G, drawing forth the lines BI, BH, and BG, and ſetting down upon the ſame (by help of my ſcale and Compaſſes) the particular dimenſions found by the Chaine, as is there expreſſed, I note the points I, H, and G.

Secondly, ſetting the Index upon the point B, I turne it forward towards A, till through the ſights thereof I ſee the Beacon there erected, to which I ſtrike a line upon the paper along by the edge of the Index as the line B A, then I meaſure it with my Chaine, finding it 45. perches exactly, which taken off my ſcale. I ſet the ſame extent, with my Compaſſes from B to A, making ſuch a marke as this (⊙) which ſhall repreſent my ſecond ſtation, from whence

whence (as before) having placed the index, upon the line AB, & set the sights thereof to cut the point B, I strike the lines AD, AE, AF, &c likewise measure them with the Chaine, making a little prick upon the Paper at D, E, and F, which shall shew upon the Table the true symetry and shape of that part of the Field.



Thirdly, the Table standing steady, and fixed upon the point of that second station A, & also rectified by the line AB (for fear the Table should be alter'd) you are then to turne the index upon the point A, towards C, and when you shall (through the sights thereof) espie the Beacon at C, draw a line along by the edge of your index towards C (which for exactnesse, extend forward and backward to the extremity

extremity of the sheet of Paper upon your Table) then measure the stationary distance A C, 43 P 20, to which open your Compasses upon your scale, and set it down from A, to C. Lastly comming to C, you are there to erect your Table, and upon the line C A set the Index, and then turne the Table gently, till through the sights, you see the Beacon at your second station A, then screwing fast the Table, direct the sights to the several angles at K, L and M, towards which (upon your paper) stike lines with the one point of your Compasses, by the fiduciall line, or edge of your Index, and then measuring the distances of every of the said angles from you, set down each measure in its own proper line respectively, as in the former figure you may perceive, so will you have the true plot of the Field. But in case that from three stations, you could not have seen all the angles in the said Field; then after you had finished these, you should have removed your Table to a fourth and there to have performed the rest, or as many as there you could, and if any remaining, to chuse a place for a fifth and a sixth station, &c. till you have finished; for the work will in effect be the same with the former.

CHAP.

CHAP. IX.

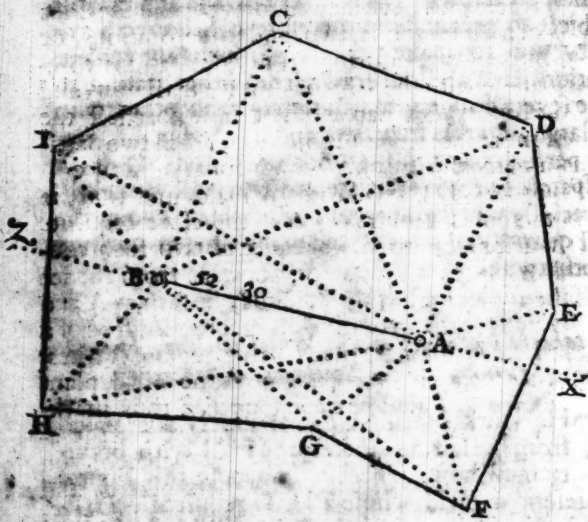
To take the Plot of a Field at two ſtations within the ſame, from either of which all the angles in the ſaid Field may be ſeen, by meaſuring only the Stationary-diſtance.

HItherto we have ſhewed how to take the Plot of a Field, at one, two, and three Stations, or more, by meaſuring from the Stations to every angle with the Chain; but we ſhall now, and in the following Chapter, ſhew how to effect the ſame more ſpeedily by Projection, from two Stations, and meaſuring only the Stationary diſtance.

Suppoſe C D E F G H I be a Field, and the true plot thereof is required. It is therefore requiſite in the firſt place, to make choice of two ſuch convenient places for your Stations, as from thence all the angles in the ſaid Field may be ſeen, as A and B, (which for the avoyding of errour, muſt be of a conſiderable diſtance) then having ſet up Whites, or other marks in every angle of the Field, plant your Table at A, where upon the point thus marked (⊙), lay the edge of your index, and turn it about towards C, till through the ſights thereof, you eſpie the White, or other mark there placed, and then by the edge of your index, draw the line A C. Secondly, turn your index towards D, and draw the line A D, and ſo in like manner proceed till you have drawn lines from your point of ſtation A, to every angle in the Field, as is lively expreſſed in the Figure.

Afterward (your Table ſtanding fixed) direct your

your ſights to your ſecond Station at B, and draw a line by the edge of your index (and be ſure to extend it far enough, that when you come to direct your ſight back again to the firſt Station, you may not fail to lay your index aright upon the Stationary-line,) and then exactly meaſure the intervall of your Stations, which in this Example we find 52. perches, 3. primes, 0. Sec. which



ſet down from A to B, then ſetting your Table at B, place the index upon the line Z,B,A,X, and turn it, till through the ſights, you eſpie the point of your firſt ſtation at A, in which poſiture let your Table be fixed; which done, lay your index upon

B

B, and direct the ſights to all the angles in the Field as you did from the firſt ſtation at A, drawing ſmall lines with the point of your Compaſſes along by the edge of the index, and at the interſections of theſe lines, are the angles of the Field, as they are repreſented upon the paper.

Notwithſtanding, this manner of working is very facile, and of wonderfull celerity, yet ſometimes, in reſpect of the acuity of the angles, it is ſubject to errour, and therefore it behooveth my Surveyor to make choice of ſuch convenient ſtations, that all lines drawn from either ſtation to the ſeverall angles, may interſect each other with as large angles as may be: and if it be but diſcreetly performed, you ſhall not only find it of quick diſpatch, but alſo accurate and marvellous uſefull, eſpecially when you would on a ſudden know the juſt quantity of a Field, and want time to meaſure it otherwiſe.

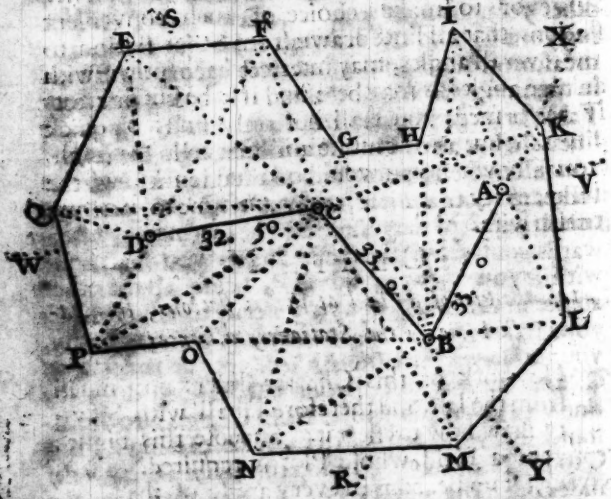
CHAP. X.

To take the Plot of a Field at divers ſtations, by meaſuring only the Stationary diſtances.

THe work of this Chapter differs not much from the laſt, and therefore I ſhall with brevity ſhew how to effect it. Suppoſe this Figure repreſent a Field, whoſe Plot is required. Firſt, having ſet up Beacons in every angle of the Field, make choice of the moſt convenient place for your firſt ſtation, which let be at A, where planting your Table, and ſetting the Index upon the point A, direct your ſights to as many angles ſeverally, as are within your view, as to H, I, K, L, and accordingly

ſtrike

ſtrike lines to every of them, as is before declared, which done, make choice of a fit place for your ſecond ſtation, where you may not only ſee all the ſame angles you behold from the firſt ſtation, but as many more as you can, which imagine at B, then upon my Table ſtanding fixed at A, I direct the ſights to B, and meaſure the ſtationary diſtance A B 33. perches; then taking up my Table at A, and planting it at B, I place the index



upon the line R B A X, and turn it gently about till through the ſights I ſee the mark ſet up at my firſt ſtation A, and then removing the index orderly, I direct the ſights to all the former angles (except K, which

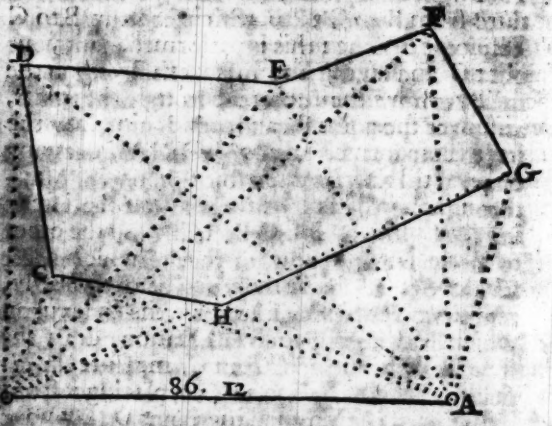
K, which I cannot yet ſee) namely to H. Ia nd L. making a little prick where theſe lines interſect the former, which done, obſerve what other angles you can diſcover, as thoſe at M, N, O and G, and to theſe direct your index, and draw ſmall lines with the point of your Compaſſes, as before, then (letting your Table ſtand ſtill at B, find out your third ſtation, as at C, where you may not onely view thoſe former angles at G, M, N and O, and the angle K, which at B could not be ſeen, but as many other yet unſeen, as you can; then from B, directing your ſight to C, till you eſpie the ſame, and meaſure from B to C 33ᵖ 0, which ſet from B to C in the line y s. When this is performed, plant your Table at C, and laying the Index exactly upon the line SCBy, move the Table till through the ſights, you diſcover the point B, and then again direct the Index to thoſe former angles G, O, N, M, drawing ſmall lines till they interſect the former. Afterwards conſider what other angles you ſhall finde within your view, as F E Q P, being all the other angles in the field, till now unſeen, to which direct your Index, and deſcribe them, as before. Laſtly, your table yet remaining fixed, ſet the Index upon C, and turn it to D (your laſt Station) draw the line V C D W, in which from C, meaſure the diſtance of your laſt ſtation 32ᵖ, 50, placing it from C to D. Now having found the point D, lay your index upon the line W D C V, and then turn the Table til you ſee the point C, and ſo placing the Index upon the point of the laſt ſtation at D, I direct it to all thoſe ſeveral angles at F E Q P, and where thoſe lines interſect the former, make ſmall marks, then draw a line from one point to another where

the lines interfect, as E F, F G, G H, H I, I K, K L, L M, M N, N O, O P, P Q, Q E, which will repreſent upon your Table, the true Plot and Simetry of the ſaid Field.

CHAP. XI.

To take the Plot of a Field remote from you, at two Stations, when you are not permitted to come within it.

IT oftentimes hapneth that you are called to meaſure a Field, and may not (either by Waters,



Mooriſh ground, danger of Suit, or other impediment) enter into the ſame, yet you ſhall finde the work eaſie enough to be performed, for it differs very little from that manner of projection in the ninth Chapter, only that there your ſtations were both made within the ground, and here they are without.

Sup-

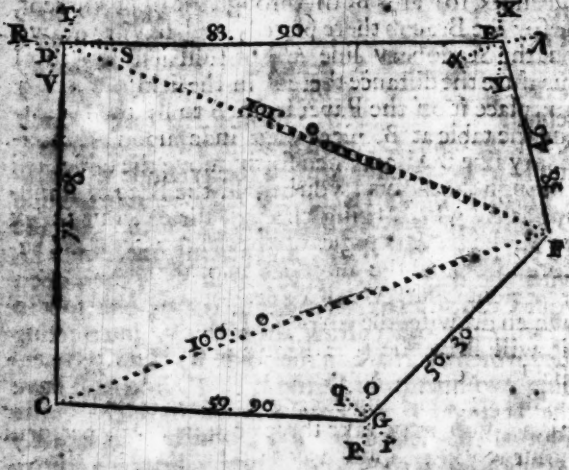
Suppose the figure *CDEFGH* be a field, wherein *I* may in no wise enter, yet of necessity must the Plot thereof be taken, and therefore *I* make choice of two convenient stations without the same, as A and B, from each of which I can see all the angles of the said field; and having planted my Table at A (the place of my first station) I place the fiducial line of my index thereupon, and direct it (as before was shewed) to all the angles of the field respectively, drawing lines with the point of my Compass, as A C, A D, A E, A F, A G, A H. Then (my table remained fixed) from A, I direct the index towards B, till through the sights thereof, I espy the Beacon there placed, and having drawn out the Stationary line A B of sufficient length, I measure the distance thereof in the field, 86 *P*, 12 *L*; and place it on the Paper from A to B, then planting the table at B, place your index upon the Stationary line B A, and then softly move the table, till through the sights, you behold the Beacon standing at A, which being effected, direct your index to all the several angles of the field, as you did before at A, and the intersection of these lines, will represent the several angles of the field, from which drawing the lines CD, DE, EF, FG, GH, HC, it will shew the true Plot and proportion of the field.

But if all the angles cannot be seen from two Stations, you may take three or four, and perform your work without, as you did within the Plot, in the last Chapter, but *I* need not further explain this matter, for he that aright understands the one, cannot be ignorant of the other they both depending upon one and the same principle.

CHAP. XII.

To take the Plot of a Field by the Chain onely.

IT may fall out sometimes that you may be requi-red to measure a field, when you have onely a Chain about you, and cannot procure a table, then in this case, you may make use of the way here delivered, which in small inclosures, where the lines are not much curved, will stand you in excellent stead.



Let this figure C D E F G represent a Field to be Plotted. First, I measure with my Chain from F to C, which contains 100^{p}, 0, then I measure the side C G 59^{p} 90, and the side FG 50^{p} 30.

Which

Which done, I open my Compasses upon the Scale to 100 P. 0, and setting one foot in the point F with the other I mark the point C, next I take from my Scale 59 P. 90. and setting one foot in C, with the other I draw the arch O P, then again with the distance F G 50 P. 30, setting one foot in F, draw the arch q r, cutting the former arch O P in then drawing two lines from F and C to G, we have the Triangle F C G exactly described, according to the tenth Problem of the first Book.

Secondly, in the Triangle CDF, the side *CD* contains 71 P. 08. and the side *F D* 101 P. 08, therefore (from my *Scale*) I take 71. 08. and setting one foot of my Compasses in the point *C*, with the other I describe the arch R S, next I take 101: 0. from my Scale, and setting one foot in F, with the other I describe the arch V T, crossing the former arch R S in the point D, then drawing two lines from C and D to F, we have limited the Triangle *C D F*.

Thirdly, In the Triangle *D E F*, because the side D E contains 83 P. 90, and the side *E F* 38 P. 46. take 83. 90. from your Scale, and placing one foot in D, with the other describe the arch X Y, then open your Compasses to 38 P. 46, and setting one foot in *F*, with the other draw the arch « », intersecting the former arch X Y in the point E. Lastly, extending two lines from D and E to *F*, you shall have the Triangle *D E F*, and so you have the entire Plot of the field *C D E F G*, which is as exactly wrought, as if the Plot had been taken by your Index upon the Table.

More examples I might add, but he that rightly understands this, may perform any other. And albeit in the former Chapters, I have sufficiently

shewed how my Reader may Plot any piece of ground whatsoever, several ways, after the most plain and easie method that can be divised (which I hope will yield abundant satisfaction to all that read and practice it) yet forasmuch as it is often required to take the Plot of a whole Manner (or any part of a Manner) consisting of divers severals, as Arrable, Pasture, and Wood-grounds, it will be here necessary and convenient, to shew you an exact and perfect way how the same may speedily be effected; and to this end, I shall in the following Chapter, endeavour to explain the same, by setting forth to your view, the best way to Plot any irregular ground, by going round about the same, and afterward shall give you a perfect and lively model and patern of a field, consisting of sundry parts, wherein each ground is to be plotted and laid down together in an intire Plot upon Paper, according to the just order and proportion, as it lies in the field.

CHAP. XIII.

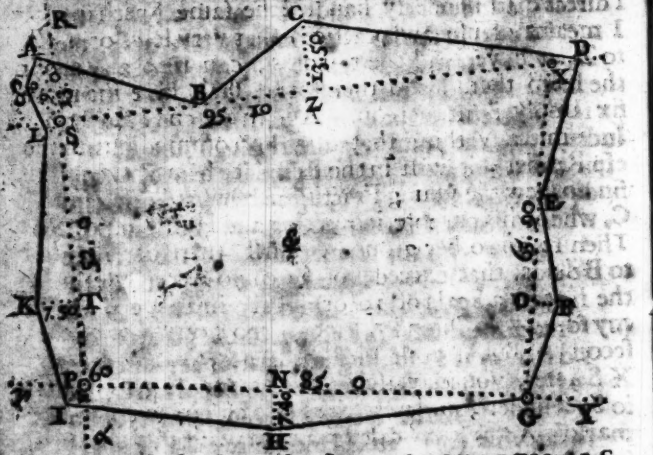
To take the Plot of a Field, by measuring from one angle to another, round about the same.

IN the former Chapters we have shewed after the most easie and artificial wayes yet invented, how the Plot of a field may be had and obtained several ways, yet because in old Inclosure, it happens for the most part, that you can seldom finde any of the Hedges straight any considerable distance, and oft times one side is bounded with some River, or other crooked Gutter, it will be requisite in this Chapter to shew you the most common and ordina-

ry

ry way used by my self, & other practical Surveyors, wch I shall here the more willingly do, in regard this manner of working (which I know by long experience to be the most absolute of all others) is hitherto neglected by all former Authors, that have written upon this subject; or at least, they have so slenderly handled the same (perhaps for want of use and practice) that very few, or none, that have read their works, can reap any profit from them, and therefore I shall here the more amply insist thereon. And to the end I might not omit any thing that may be commodious to the Reader, it will in the first place be very requisite to shew the young Practitioner what Scale is most fit for his purpose, in plotting and laying out inclosure, and other grounds. First, therefore in small Fields, that exceed not 60 or 70 Acres, you may plot by a Scale of 10 or 12 parts in an inch, and so bring your intended Plot all upon one sheet of Paper. But if your Field be larger, and under 200 Acres, you may use a Scale of 16. If greater, and yet under 300 Acres, the Scale of 20, but if under 500 Acres the Scale of 24, may serve your turn, however those of 16 and 20 in the inch, are the ordinary and common Scales now used, for though your ground contain 500, 1000, or 2000 Acres, yet may the Surveyor very aptly use them, by shifting of Paper, and afterwards in the house, putting the several sheets together with Mouth-glew, and so make an entire Plot thereof; yet if your field consist of three or four thousand Acres, and you would have the Plot of a less proportion, you may use a Scale of 24 or 32 parts in the inch, though for my part I never yet, these 25 years, that I have (in a

manner) daily practiced the Art, ever used any Scale above 24. But because I would not exceed my intended limits, neither have the Diagrams too large for an ordinary Octavo, I shall (as before) in all my examples, make use of a Scale of 32 in the inch. But to my purpose.



Suppose this irregular figure ABCDEFGHIKLS represent a Field, into which when I first enter, I cause whites to be set up in every corner of the same, which done, I make choice of the most convenient angles thereof for my Stations, not regarding their number, whether I make 3, 4, 5, or 6. Stations, yet the fewer the better, but you must always take so many, as you may clearly see from one to another. Thus in the former figure, I make choice of my first Station at X, as a place most fit for my purpose, in regard that from thence I can see the

point

point L, and therefore I send one with a Beacon to S, so as when I go on in the line X S, I may make a tangent at B, then planting my Table at X, I direct my Index to D, and strike the line X D, which I measure, finding it 5^{p} 30, and this I set down from X to D, and so make a prick at D; this done, I direct the Index to S, and strike the line X S, then I measure on in the said Stationary-line, till I come to Z, 47^{p} 30 from X, where laying my Index upon the line S Z X, I direct the sights to X, and there fix the Table with the Screw-pin, then turning the Index upon the point Z, till through the sights I espie the white at C, I then strike the line Z C, and finding the distance 13^{p} 50, I set it down from Z to C, where I make a point, and draw the line D C. Then I go on with my former measure till I come to B 68^{p} 40, and there I make a point, and draw the line C B; which done, I go on carefully with my former measure, till I come to the place of my second station at S, finding the stationary-distance X S 95^{p} 10, which from my Scale I apply from X to S, where I make for my second station such a mark as this (☉) then planting my Table there (as I shewed before) I direct my sights to A ♂ and L. and I find S A 13^{p} 0, S ♂ 9^{p} 0, and S L 3^{p} 0, which set down severally upon their respective lines, I have the points A, ♂ and L upon the paper, then drawing the lines A B, A ♂ and ♂ L, we have one side of the Field described,

Secondly, I plant my Table at S, and laying the fiduciall line of the Index upon the line S X, I move the Table till through the sights I espie the point X, then fixing my Table, I turn my Index about upon the point S, till through the sights I see the Beacon

at P, and by the edge of the Index, I draw the line S P; which done, I proceed, and measure on the stationary-distance, but as I go on, and am come to T, 35ᵖ from my second station, I observe I am in a manner against the angle K, wherefore I plant my Table there, and direct the sights to K, then I measure the distance, finding it 7ᵖ 50, which I set down from T to K, and draw the line L K, which done, I continue my former measure S T to P, and finding it 52ᵖ 0, I set it down from S to P, where again I make such a mark, (⊙)

Thirdly, I plant my Table there, and laying my Index upon the line P S K, I turn the Table about, till through the sights I see the place of my second station S, then (the Table being there fixed) I direct the sights of my Index from P to I, and finding it (by the Chain) to contain 4ᵖ 60, I set it down from P to I, which done, I describe the line K I with the point of my Black-lead Pencill, as before. Afterwards from P, I direct the sights to my last station at G, and draw the occult line P G, then I measure on with my Chain from P towards G and when I come to N 37ᵖ 10, (where I make a prick with the point of my Compasses) I perceive I am almost against the angle H, then laying my Index upon the line P G, I turn the Table till I espie G with the fore-sight, and P with the back sight (by which you may know whether you be exactly in the line or no,) which done, fix your Table, and direct your sights from N to H, pricking down the distance 7ᵖ 40, and so with my Pencill describe the line I H, and after this is done, continue on your former measure began from P, till you come to G (your last station) which you shall find to be 85ᵖ 0, which set down

to

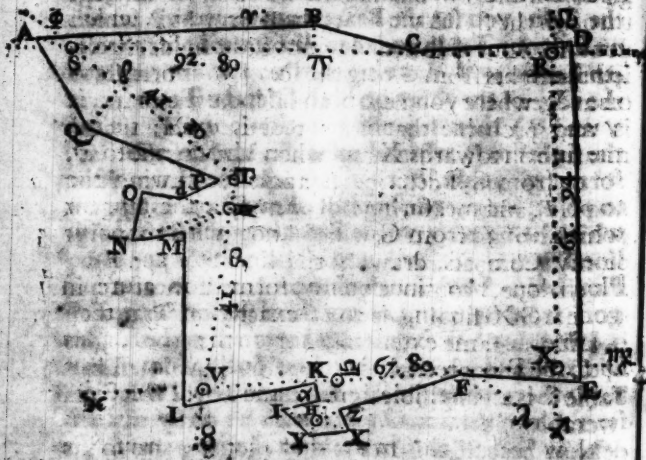
to G, and mark it again thus. (⊙)

Lastly, at G plant your Table, and lay the Index exactly upon the line Y G P ♈, then turn the Table gently (for fear of shaking the Index off the line) till through the sights you espie the Beacon at P, which done, fix your Table, and remove the Index, directing the sights from G to the place of your first station at X, where you began, and if it cut the mark, it is very probable that your plot is exact; then I measure on towards X, and when I have gone to ⊙, 18ᵖ 60 from G, I describe the angle F, drawing the line G F, and measuring still on, I find the tangent point E 39ᵖ 30 from G, which I note with the point of my Compass, drawing the lines F E and E D; which done, I continue on my former measure in the line G X, finding it to be exactly 65ᵖ 90, then because the same extent taken from the Scale, falls upon the Plot precisely in the point X, where I first began, it is an infallible sign that the plot of the Field is exactly taken.

Now because this manner of plotting ground is the most excellent of any other, and is that which the Surveyor shall find at all times most apt for his purpose, it will not be amiss to give you another example, where a Field runs out into many irregular nookes and corners, wherein I shall use all possible brevity, giving you only a short demonstration, in regard I have explained the former figure so fully already, so that he that knows how to perform this one, may quickly apprehend the work of the other: for they are both grounded upon one and the same Geometricall principle.

Let us suppose this figure noted with the letters A B C D E F Z X Y I K L M N O d P Q be a Field, whose

whose plot is required. First, (when you have set up Beacons in every angle thereof) plant your Table at R, and from thence direct the sights to S, re-



membring as you measure on the line R S to mark the tangent at C, which falls out at 26° 30, and after you have measured on to ♐ 45° 70, take the distance of that angle from your stationary-line at ♐ 4° 60, which note as before, then measuring on to S, you shall find the whole length of the stationary line R S to be 91° .80, at the end whereof mark the point S. Afterwards setting your index upon the said stationary line, turne the Table, till through the sights you see the Beacon at R, and there fix it, then direct the sights from S to T, and as you measure on that line, remember when you come to ♑, to take the angle Q, as before was shewed, but go on still,

measuring

measuring the ſtationary line to T 41° 10, and on your paper at T, make a mark thus (⊙) for your ſecond ſtation ; and this being done, lay the Index upon the line ♈ T S ♎, and turn the Table, till through the ſights you ſee the Beacon at S, in which ſituation fix your Table, and then direct the ſights to your 4th ſtation at V, drawing the line T V (noting it on the edge of the paper on both ſides the Table, as at ♈ and ♉) then from my ſtation-point T, I direct the ſights to P, which I meaſure, and deſcribe, as I formerly taught, drawing black lines from point to point, for the out-bounds of my Plot, as I go on; which being performed, I meaſure the ſtationary-line T V 41° 50, and mark the point V upon my Plot, but as I was meaſuring on that line, and had gone from the point of my third ſtation T to ♊ 6° 0, I find that a convenient place to take the angles D O N and M, and therefore ſetting down my Table there, place the line T V upon my Table, anſwerable to that in the Field, which I do by my Index, as before is ſhewed, then I direct the ſights ſeverally to all the ſaid points, and after they are meaſured, let them be ſet down upon the Paper, as before.

Fourthly, plant the Table at V, and laying the fiducial edge of the index on the line ♉ V T ♈, turn the Table, till through the ſights you ſee the Beacon at T, then fix the Table, and from the point V direct the ſights to L, deſcribing it as formerly. Afterwards (your Table being ſtill fixed) ſet your ſights from V to X, and as you meaſure on that line, and are gone from V 21, 95, that you touch the hedge at K, there make a mark, and deſcribe the line L K, and when you come to ♌ 26° 0 from V, I find it a

fit

fit place to plant my Table, directing the sights to V ♓, and then (screwing fast the Table) I set up a Beacon at H, near the Angles I Y Z X, and going back to ♎, I direct my sights to H, and finding the distance 9 P. 0, I set it down from ♎ to H, then I plant the Table at H, and laying the Index upon the line H ♎, I turne the Table till I espie the point ♎, in which scite (when I have fixed the Table) I lay the Index upon the point H, and strike the lines H a, H I, H Y, H X, H Z, which measure and describe, as hath been shewed; then goe back to your stationarie line V X, and continue on that measure formerly began, till you come to the Tangent point F 50 P. 0, from V, where make a mark with the point of your Compass, and draw the line Z F, and keeping on measuring to X, I finde it 67 P. 80. Lastly, planting the Table at X, in its due order, direct the sights to E, striking the line X E, then measure its distance and set it down as before, drawing forth the lines F E and E D, which done, lay the index upon the line ♑ X R ♌; and if through the sights you espie the point R, where you began, it is an Argument your Work is good, but for further trial of the truth thereof, you are to measure the line X R upon the ground, and if it agree exactly with your Plot, it shews that the Plot is truly taken.

In like manner you may take the Plot of a Wood, or other moorish ground, by going round about, and making observation at every angle, as you see it performed in the Work of this Chapter.

There is one thing necessary to be observed, that when you are plotting of Ground, how you may know

know by your Chard and Needle whether you ſet your index upon the right line, or not, for ſometimes when you have many lines upon your Plot, and are in haſt of buſineſs, you may ſoon (through the multiplicity of lines) commit an errour of this kind, and ſo when you come to cloſe your Plot, you may diſcover your errour, and not before: to avoid this inconvenience, you are (as ſoon as you have planted your Table at your firſt ſtation) to obſerve at what degree the Needle ſtandeth, and if you work true, and miſtake not your line, you ſhall finde it ſtand upon the ſame degree, at every ſtation round about the Field; but if there be any errour in your work (as there muſt of neceſſity when you direct the index back upon a wrong line) then will your Needle ſtand upon ſome other Point diſtant from the former, in which you began, which will be more or leſs from the ſame, anſwerable to the reflection of the line you took from the true one. Let me therefore adv c, that at every ſtation you have ſpecial regard hereunto; ſo that if you chance at any time to fail, you may rectifie your errour, before you depart from that ſtation.

And now I am ſpeaking of the Chard and Needle in your Table, I will not adviſe you at any time to plant the Table onely thereby, as ſome do; for I well know it is too ſmal and inſufficient for that purpoſe; but rather (as I have all along taught) to make uſe of fore-ſight and back-ſight, from ſtation to ſtation round about the Field. And thus much I thought fit to admoniſh you of,

CHAP.

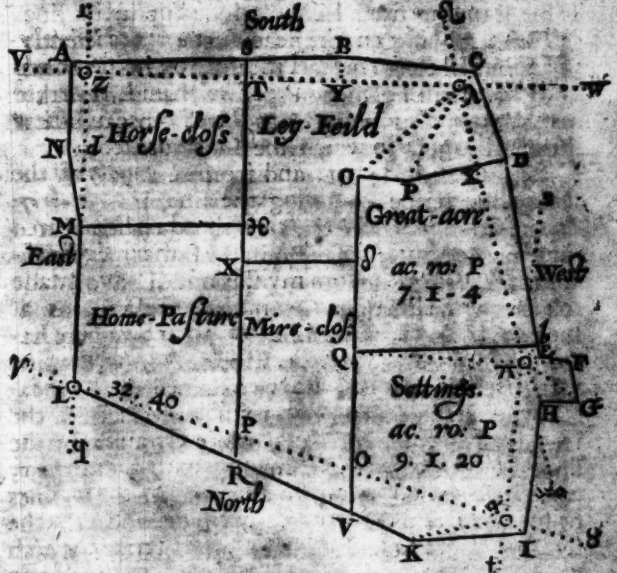
CHAP. XIV.

To take the Plot of a Lordship, or Mannour, consisting of divers small Fields, Pastures, Wood-grounds, and the like.

HAving in the former Chapters sufficiently taught how to Plot all manner of Grounds whatsoever, I shall not here particularly reiterate my former Demonstrations, and yet shall shew how you are to proceed about the same.

Suppose this Figure, or Diagram, be part of the Mannour of *Burton-Lazers*, near *Melton-Mowbrey*, in the County of *Leicester*, which is to be measured and plotted. First therefore, according to the directions before delivered, (after I have made choice of convenient places for Beacons, as at c, w, A, and L) I plant my Table at c, where having described the Angles I and K, I draw the line K I, then I direct the sights to w, to which I measure, and there planting the Table, I direct the sights severally to H, G, F, e, b and Q, and by the help of my Scale and Compasses I describe them, as formerly hath been shewed, drawing the lines I H, H G, G F, F E, e b, and b Q. Next (the Table remaining fixed) I set my sights to A, which I measure, finding it 56 r. 55; but as I come on to X 39 r. 0 from w, I intersect the Hedge D P O in the point X, which I note with the point of my Compass. Again, I plant my Table at A, in such manner as hath been formerly taught, and describe the lines A C, A P, A O, which I measure severally,

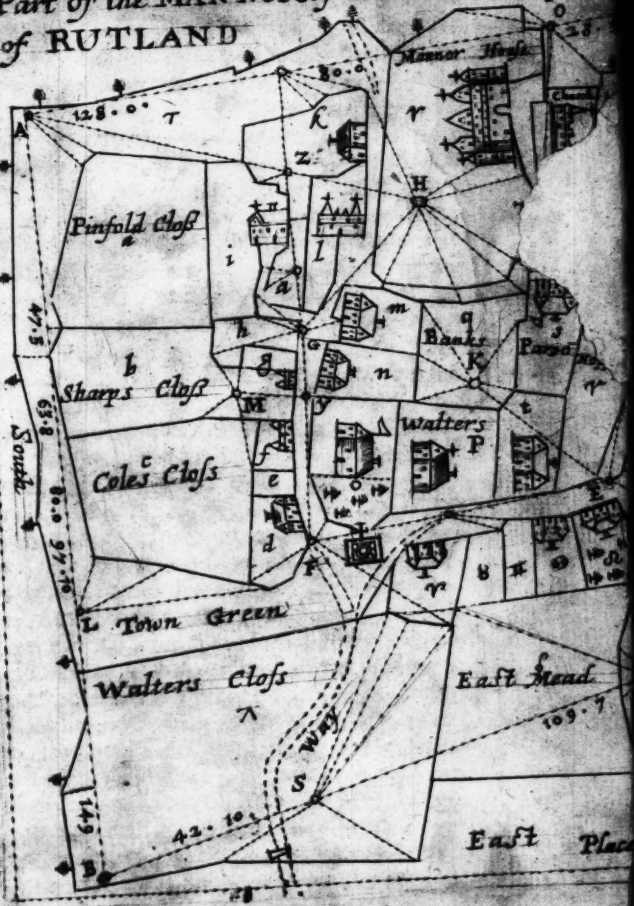
verally, and ſet them down from my Scale, drawing the lines E D, D C, D P, P O, then directing the ſights from A to Z, I meaſure the diſtance 71 P. 60, which I prick down from A to Z, and mark the point Z; but as I go on that line, when I come to Y, I take the depth of the Angle B; P. 0, which I deſcribe as in the Figure; drawing the line C B;



and likewiſe when I come to T, and interſect the Hedge T P, I make a mark there; and being arrived at Z, I plant my Table, where I rectifie the ſame in all reſpects, as is ſhewed in the former Chapters; which done, I deſcribe the Angle A,

then I set the sights to L, and measure the line, but coming to ν, I describe the Angle N; and after I have measured 29 P. 80 from Z, I touch the Hedge at M, where I make a Prick, drawing the lines AN, and NM. Afterwards measuring on to L 61 P. 50, I describe the line ML, then I plant my Table at L, directing the sights back to Z, and the Table standing fixed, I lay the index upon the line γ L a 8, and if it cut the Beacon at a, there is hope the Plot will close: next I measure on in the same line, and when I come to P 32 P. 40 from L, I make a mark, drawing a line from P to S, (because the line is straight) in which line I measure from P to X, and finde it 34 P. 0; and from X to ϰ 9 P. 60, which I describe, drawing the line ϰ M, so is *Horse-Close* and *Home-Pasture* finished: Then I continue my measure forward in the same line, till I come to O 56 P. 80, from my station at L, and there making a mark, I draw the line O ♃ O; and then I measure on in the same line to ♃ 41 P. 10, and draw the line ♃ X, which done, I perceive the whole work is finished, and I have obtained the Plot of the whole Field, and every ground contained therein. And if there had been more Grounds, you should have dealt in like manner with them, and proceed from one Close to another till the whole be finished: and if there be any Houses and Homesteds, you are to take them in, and describe them; as also all *Streets*, *Lanes*, *High-wayes*, *Mills*, *Trees*, and the like; but Practice, better then many Words, openeth this: Yet one thing in this manner of working I cannot omit, that when you come to take the Plot of a Town that is spacious, (which commonly lies within the body of your Plot)

Part of the MANNOR of L. in the County of RUTLAND



Plot) you must proceed from *Street* to *Street*, and from *Lane* to *Lane*, describing all the said *Streets*, *Lanes*, *Houses*, *Homesteds*, and other edifices, which lie within your view as you go; and if you cannot conveniently go about them, then at Gates, or other open places, you must (from your main Stationarie-line) make little inward Stations, in meet and convenient places, which you shall finde very commodious in making a true Plot. But if you can pass through back Lanes with your Table, and have the liberty to make fit Stations on the out-sides, it will better serve your purpose; but I leave this to your own consideration, not doubting but that from what is already said, you will be throughly enabled, not onely to take the Plot of a single Field, but also of a whole *Mannour*, when ever the same is required.

Having now shewed you (with some brevity) after what manner you are to proceed about taking the Plot of less and greater quantities, and many severalls together, as a whole Lordship or *Mannour*; and what course is most fitting in laying down and describing the true proportion and symmetry thereof upon Paper; (which I might have done after a far larger method; but I should then not onely have been more tedious and Prolix, but also more obscure, and less profitable to my Reader:) and therefore it may suffice to give you onely the Plot of a part of a *Mannour*, by which you may by inspection, and the help of what hath been afore delivered; see the whole progress of my proceedings in doing the same, and may thereby be able to do the like, as oft as occasion shall require it.

CHAP. XV.

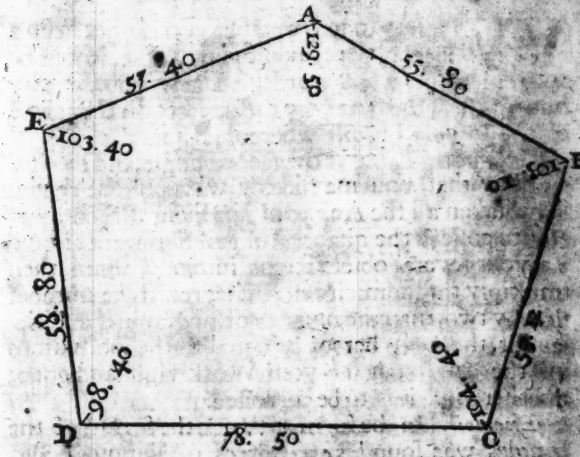
To take the Plot of a Field by the degrees on the frame of the Table.

WHereas in wet weather you cannot keep a sheet of paper upon your Table, it will be convenient, in a few words, to shew you the way how to effect the same, by the degrees on the frame of the Table. The use whereof is thus.

Place your Table at the second angle, and having screwed it fast, turn the index about upon the centre, till throw the sights, you espie your Beacon erected at the first angle, and note the degree cut by your index upon the frame of the Table; then turning your index about, direct the sights thereof to your Beacon set up at the third angle, and observe the degree there cut upon the frame, and so by the difference of them you shall have the quantity of the angle at your first Station: then measure the distance, from the first Angle to your Station, which you are to note down in your Book, as also the quantity of the Angle before taken; next measure on to your second Station (which is the third Angle) and there plant your Table, as before, taking the quantity of the angle there made, and the Stationary-distance, both which insert in your Book. And so proceed from one angle to another, till you have finished the whole Field, taking the quantity of every angle, and all your Stationary-distances, as shall be more fully declared in this following Example.

Let

Let *A B C D* be a Field to be meaſured, and being wet and moiſt weather, I cannot put a ſheet of paper upon my Table, therefore, after I have ſet up Beacons in every angle of the Field, I firſt meaſure the ſide *E A* 57 P. 40, and then I plant my Table at *A*,



from whence I direct the ſights to *E*, and I finde it cut upon the Frame at 30 degrees 10 minutes: next from *A*, I ſet the ſights to *B*, and finde it to cut at 160 degrees 0 minutes, the difference is 129 degrees 50 minutes, which is the quantity of the Angle at A, which I note in my Book, as alſo the ſide E A. This done, I meaſure on from *A* to *B* 55 P. 80, and at *B* I again plant my Table, where I finde (according to the former directions) the quantity of that angle 103 deg. 10 m., which I ſet down in my Book, together with the ſide *AB*; and in this manner

I proceed from Angle to Angle, and from side to side, till all is finished: so in this example will all the observations taken in my Book, stand thus.

		Gr.	Min.			Per.	Pts.
Angles:	A	129	50	Sides	A E	57	40
	B	103	10		A B	55	80
	C	104	40		B C	55	12
	D	98	40		C D	78	50
	E	103	40		D E	58	80
Sum.		540	00				

Now that you may know whether or no you have taken all the Angles of the Field exactly, you are to collect the quantity of all the Angles found at your several observations into one Summ, then multiply the Semicircle 180 degrees, by a number less by two, then the number of Angles in the Field, and if the factus hereof be equal to the total summ of the Angles, then is your Work right and good, if otherwise, it is to be corrected.

Example. In the former Work the summ of the Angles was found 540 degrees 0. Minutes, and their number 3, therefore I multiply 180 by 3, (which is less by 2 then the number of the Angles) and the product 540 degrees 0. minutes agreeing exactly with the summ of all the Angles in the field, it argues that the Work is exactly performed. The Geometrical ground hereof depends upon these two Propositions.

1. *In omni Triangulo tres Anguli simul sumpti, sunt duobus rectis æquales.* Euc. 1. 32. Ra. 6. 13.

In every Triangle, the summ of the 3 Angles are equal unto 2 right Angles, according to our first Book and 7th. Problem.

2. *Cu-*

2. *Cujuscunque Triangulati Latera sunt binario plura Triangulis a quibus constat.* Ra. 10. 2.

The sides of a Triangulate are more by two then are the Triangles of which it is made, as you may see in the eighteeeth Problem of our first Book.

Note that this Rule holds good when all the Angles of the Field are inward Angles, or less then 180^{d}., but if greater, you are to take their Complements, and then work as before.

Now having taken the quantity of all the Angles and sides of your Field, I will here shew you how to protract, and lay down the same upon paper.

1. Therefore having drawn forth the line A B upon paper, place the centre of your Protractor upon the point A, and lay the scale thereof upon the same, from which line (upon the semicircle of your Protractor) set off the quantity of that Angle 129 degrees 50 minutes, and draw forth the line A E 57^{P} 40 from your Scale, and the line A B 55^{P} 80.

2. Lay the centre of your Protractor upon the point B, and the side thereof A B upon the line B A before described; and upon the Semicircle of your Protractor set off the Angle B 103 degrees 10 minutes, drawing forth the line B C 55^{P} 12 by your Scale and Compass.

3. Lay the center of your Protractor upon the point C, and place the side thereof A B upon the line C B, from which (upon the semicircle) number 104 degrees 40 minutes, where make a mark, and through it draw the line C D, setting 78^{P} 50 thereon, from C to D.

4. Bring the centre of your Protractor to the point D, and set the side A B thereof upon the line D C, from which (in the limb of the Semicircle)

number the quantity of that angle 98 degrees 40 minutes, where make a ſmall mark, and through it draw the line DE, the length thereof being 58ᵖ. 80.

Laſtly, lay the center of the Protractor on the point E, and the ſide thereof A B on the line E D, then in the limbe of the Protractor, accounting 103 degrees 40 minutes from the ſaid line E D, you ſhall find it to cut exactly the line E A, formerly deſcribed upon the Paper, leaving the ſide E A to contain 57ᵖ. 40.

Thus have you now protracted the ſaid Field, according to the obſervations you made by the degrees on the frame of your Table: but you ſhall find that practice, better then many words, will make this apparent; however this manner of working, as it is more troubleſome and difficult then any of the former wayes before deſcribed, ſo may the Surveyor be ſooner miſtaken in it, then in any of the reſt; and therefore as I have placed it laſt in order, ſo I would never have my Surveyor uſe it, but when neceſſity compells him, as in wet and ſtormy weather, and the rather, becauſe it takes up more time and labour then ordinary, to little purpoſe; but I leave it to the conſideration of the Reader, to whom (I hope) I have given abundant ſatisfaction in the preceding Chapters.

CHAP. XVI.

Of the meaſuring of Hills and Dales, with the beſt way of Plotting thereof.

FIrſt, take the Plot thereof by the Perimeter, according to the 13 Chapter, and reſolve it into the greateſt Trapezium that the Plot will bear,

bear, then let fall Perpendiculars to the Base; which done, go into the Field, and measure with your Chain those lines which represent the Base and Perpendiculars, which you shall finde longer then those lines in the Plot, and cast up the Plot by those numbers; not by those lines, and you shall have, not onely a true Plot thereof, but also the just quantity and content, as the ground is unlevell. Other wayes I could shew you, but being troublesome, and not so exact as this, I will at this time omit them.

CHAP. XVII.

To finde the just quantity, or content, of any piece of Ground.

ALthough in the third Book I have shewed how to measure the superficies of any regular Figure whatsoever, as the Geometrical-square, Parallelogram, the Triangle, Trapezium, the Circle, and the like; and also how to measure any irregular Figure: yet I hold it necessary to adjoyn one example more, which will illustrate the use thereof more fully.

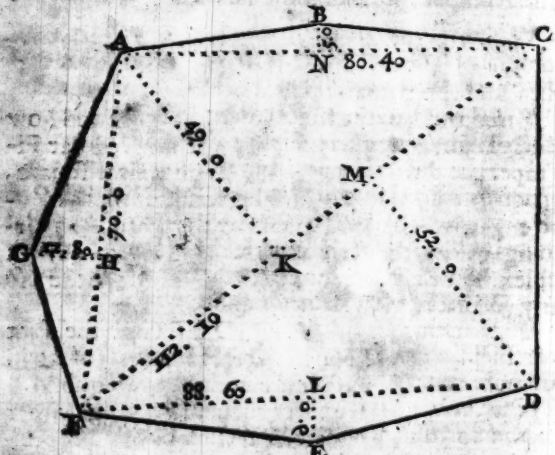
Suppose this Figure A B C D E F G be the Plot of a Field, drawn upon the Table by a Scale of 32 in an inch, and the exact content thereof is required.

Now, because it is an irregular Plot, lying neither in the form of a Square, Parallelogram, Trapezium, nor Triangle; therefore it must be reduced into some of these forms, which to effect, I first reduce the maine body of the Field into the Trapezium A C D F, and the residue of it into three Triangles, as A B C, D E F, and A F G.

Then

Then to know the just quantity of acres the Field contains, I first measure the Trapezium A C D F, to which end I take the length of the perpendicular D M from my Scale 52 P 0, and the length of the perpendicular A K 49 P 0, which I add together, and they make 101 P 0, which I multiply in halfe the base C F 56 P 05, and the product 5661. 05 is the content of the Trapezium A C D F.

In like manner for the Triangle A B C, I multiply half the Base 40.20 by the perpendicular B N 5 P 0, and the Product is the content of the Triangle A B C 201 P 00.



So for the Triangle A G F, I multiply half the Base 35 P 00, by the Perpendicular G H 12 P 80, and the Product 448 P 00 is the content of that Triangle.

Likewise

Likewise in the Triangle D E F, the Base D F is 88 P. 60, and the Perpendicular E L 9 P. 0, therefore I multiply the half base 44 P. 30 by the perpendicular 9 P. 0; and the factus 398 P. 70, is the area, or content of the Triangle D E F.

Lastly, I add the several sums together, and they give the content of the whole Figure.

The Area, or Content of the	Trapezium A C D F	5661. 05
	Triangle A B C	201. 00
	Triangle A G F	448. 00
	Triangle D E F	398. 70
The Area, or content of the whole Field.		6708. 75

Which being reduced into acres, yieldeth the content of the said Field 41 acres, 3 roods, 28 perches, and three quarters of a perch.

After this manner you may cast up the content of any irregular Field, by reducing it into Trapezias and Triangles, and adding their several products into one summ, which ought heedfully to be regarded, as being one of the most material things belonging to the practice of a Surveyor; for unless he be perfect herein, he can never perform any Work of that nature aright.

CHAP. XVIII.

To reduce Perches into Acres, & contra.

ACcording to the Statute of 33 *Ed.* 1. *De terris mensurandis, & de compositione ulnarum & Perticarum*, it is ordained, *That* 3 *grains of Barley, drie and round, do make an inch*; 12 *inches do make a foot*;

foot; 3 feet do make a yard; 5 yards and a half do make a Perch; and 40 Perches in length, and four in breadth, do make an acre. So that 16 feet and a half (quare is a perch, according to the Statute, and 160 of these Perches make an Acre; when therefore you are to reduce any number of Perches given, into acres, you must divide the number given by 160 (which are the number of Perches contained in one acre) and the Quotient will shew how many acres are therein; and if any Perches remain after your division, and that number exceed 40, divide again by 40, and the Quotient will shew the Roods, and the remainer Perches: Example, Suppose you were to turn 547 P. into acres, therefore first I divide 547 by 160, and the Quotient will be 3, and 67 remaining, which divide by 40, the Quotus will be 1, and 27 remaining; So that it amounteth to 3 acres, 1 Rood, and 27 Perches.

Again, If you would reduce 6708 perches into acres: Divide (as before) by 160, and the Quotient will be 41; and 148 remaining, which 148 being divided by 40, the quotient will be 3, and 28 remaining, so that the true quantity in acres will be 41 Ac. 3 R. 28 P.

But you may with more celerity reduce your perches into acres, if you cut off the first figure of your summ towards the right hand, and then divide the summ remaining by 4, and the work will stand thus,

In this Paradigm, the 167 are so many Roodes, and 28 Perches remaining.	2 6708 167

Then

Then in like manner divide 167 by 4, and the Quotient is 41, and 3 remaining; So will the ſumm of the Perches given contain, 41 acres, 3 Roodes, and 28 Pole.

	3
	167
	4
	41. 3. 28

CHAP. XIX.

To reduce Statute meaſure to cuſtomary meaſure, and the contrary.

ALthough an acre of Land, according to the aforeſaid Statute of 33 *Edward the Firſt*, is to contain 160 ſquare Perches, of 16 feet and a half to the Perch; yet in regard that in ſome places of the Nation, through long cuſtom, there is at this day, other Perches uſed, as 18, 20, 24, and 28 feet to the Perch; it is therefore neceſſary to ſhew my Surveyor how he may readily reduce Statute meaſure into Cuſtomary, *&c.*

Suppoſe therefore you would reduce Statute-meaſure to Woodland-meaſure, of 18 feet in the Perch, then ſay,

As the ſquare of the greater Perch of 18 feet, is to the ſquare of the leſſer Perch of 16 feet and a half: ſo is the content in acres, according to the leſſer Perch, to the content in acres, according to the greater Perch.

Let it therefore be required to reduce 36 Ac. 2 R. 10 P. at 16 feet and a half to the Perch, into Woodland-meaſure of 18 foot Perch. *Firſt*, You muſt obſerve that the ſquare of 16 feet and a halfe is decimally 272. 25, and the ſquare of 18 feet is 324;

then

then I reduce the ſaid 36 Ac. 2 R. 19 P. into Perches, which make 5850, then I multiply the ſame by the ſquare of the leſſer Perch 171. 25, and the Product 1592662. 50 being divided by the ſquare of the greater perch 324, the Quotus is 4915. 62. $\frac{1}{2}$

Otherwiſe, You may finde out the leſt proportional terms between 18 and $16\frac{1}{2}$, which by their abbreviation by $1\frac{1}{2}$, you ſhall finde to be 12 and 11; then ſquare theſe two ſumms 12 and 11, which produceth 144 and 121, which done, reduce your 36 Ac. 2 R. 10 P., into perches, and they make 5850, as before; then multiply the ſquare of 11, which is 121, by 5850, and it produceth 707850, which I divide by 144, and the Quotus is 4915, $\frac{1}{8}$, which reduced into acres, is 30 Ac. 2 R. 35 P. $\frac{1}{8}$.

But, ſuppoſe you would reduce Wood-Land meaſure into Statute meaſure, then ſay,

As the ſquare of the leſſer Perch of 16 feet and a half, is to the ſquare of the greater Perch of 18 feet: ſo is the content in acres according to the greater Perch, to the content in acres, according to the leſſer Perch.

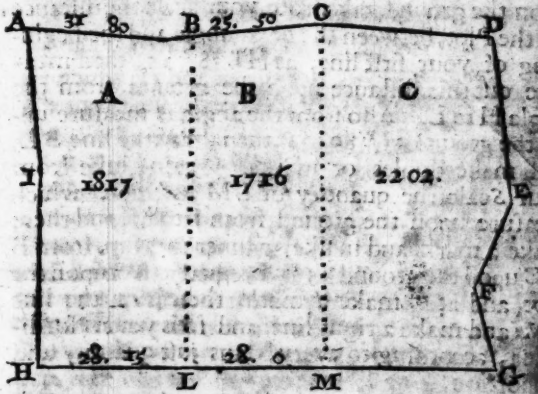
As in the former Example, I multiply the 4915 P. 62 $\frac{1}{2}$, given according to Wood-Land meaſure, by 144, the greater ſquare, and the product is 707850.00 which divided by the leſſer ſquare 121, the quotient is 5850 Perches, which reduced into acres, is 36 Ac. 2 R. 10 P.

The like courſe is to be obſerved in all reſpects in the reduction of other quantities, of what proportion ſoever, as thoſe of 12, 20, 24$\frac{1}{2}$ and 28 feet to the perch; and thus much briefly for the Reduction of Statute-meaſure into Cuſtomary, and the contrary.

CHAP.

CHAP. XX.

To divide a common Field, or Paſture into as many parts as ſhall be required.



LEt this Figure, noted with the letters A B C D E F M L H I be a Common, or Paſture, in the uſe and occupation of three *Men*, as A B C, and it is mutually agreed by them all, that each man ſhall have his proportion of ground laid out, according to the quantity of his Common in the ſame place. Firſt, meaſure the whole Field, and it will be found to contain 35 Ac. 3 Ro. 15 P. or 5735 P, then conſider how many Beaſt Gates there are in the Paſture, and divide the quantity of the Field to them accordingly by the rule of Proportion thus, ſaying, If the whole number of Beaſt-Gates of A, B and C, give the whole quantity 5735, what ſhall the number of them belonging

longing to *A* be? and the answer will be his part, and so work severally for the 3 parts. But we may suppose them thus; to A 1817, to B 1716, and to C 2202, then to lay out every Mans Plot, I divide the figure according to the directions in the fifth Book, by the lines B L and C M, which to lay out upon the ground, take from your Scale the distance on the Plot, between the next angle and the beginning of your first line, as H L 28 P. 15, then measure out this distance upon the ground, from the angle H to L. Also from the angle *A* measure upon the ground 21 P. 80 to B, then draw the line B L, and make dooles, or marks. Again, take from your Scale the quantity of L M 28 P. 00, which measure upon the ground from L to M, and there make a mark, and in like manner measure from B to C upon the ground 25 P. 50, equal to B C upon the Plot, and at C make a mark, then draw the line C M, and make a right line, and so is your Plot divided, according to every Mans just quantity and proportion.

And in this sort you may divide any spacious Common, or Wast whatsoever, into as many parts as the same shall be required. And thus much briefly shall suffice to have spoken concerning the division of common Fields.

CHAP.

CHAP. XXI.

Shewing the best way of measuring the severall and particular quantities of Arrable-Land, Leys, and Meadow, lying in the open or common Fields: with short directions for the taking in, and inclosing a Lordship.

FOr as much as this present Age hath so highly affected Inclosure, that a very great quantity of Land in the Nation is now reduced to that kind of quality, which before lay open, and in common; and seeing more is daily going in, and much more like to follow, it may therefore be expected, that I should give some directions about that matter, and shew what course is most requisite to take in the prosecution thereof. When therefore the Surveyor is to proceed about the Survey of a Lordship or Mannour, wherein the Lord and Freeholders are agreed to improve it, in laying each Mans Land together, in severall by it self (which in all common Fields lies dispersed, in many small parcells) it will be convenient to begin at one side of the Field, and there set down the name of the first furlong in your Field-Book, and upon what point of the Compass you begin. And to the end you may the better express the just length, breadth, and quantity of each part and parcel of every Mans Land, as it shall rise in order; it will be necessary to provide a Book, of a quire of paper at the least, wherein each page is to be divided into 6 columnes, so as the two first towards the left hand shall serve for the breadth of the Lands at each

end: the third, or greater columne, ſhall contain the butting, bounding, and number of every Mans particular Lands, Leys, Doles of Meadow, or the like; and the fourth, fifth, and ſixth, for the reduced breadth, length, and quantity.

Next, after you have thus done, and are come to the Furlong where you begin, expreſs in your Book the name of the Field, and particularly of that Furlong; then in the middlemoſt, or greater Column, put down the name of the Freeholder that firſt begins it, with the number of his Lands; againſt which, in the two firſt Columns towards the left hand, write the breadth of the Lands at each end, and in the three laſt put the reduced breadth, length, and quantity; which done, ſet down the name of the Freeholder that lies next, and the number of his Lands, together with the breadth, length, and quantity, as before. Afterwards ſet down him that riſeth next, with his particular breadth, length, and quantity, and ſo proceed in order, till you have finiſhed the Furlong.

Having compleatly finiſhed one Furlong, go on to the next, where you are to write the name thereof, and upon what point you enter, and then ſet down the particular quantities of ground belonging to each Land-holder, as they riſe in order, till you have finiſhed the ſame, as was before declared; afterwards go on to the third Furlong, and do the like there, and ſo on, from one Furlong to another, till you have finiſhed the whole Field.

But that you may more fully underſtand the perfect form and manner thereof, I ſhall (with much brevity) ſhew you, in the following example, an abſolute method, how you may ſpeedily effect the ſame.

The

The Form of the Field-Book.

North-*Luffenham Com. Rutland.*

Oldhams-Hedge Furlong, beginning West, at the way leading to *Edith-Weston.*

5	7	4	15	*Sam. Hunt* 2 Lands	5	1	28	0	141	40
6	6	6	0	*Ionathan Barker* 3 l.	6	3	28	0	172	20
8	18	8	14	*Sam. Hunt* 5 lands	8	16	28	4	248	16
1	5	1	13	*Vincent Wing* 1 land	1	14	28	6	48	11
24	0	23	8	The *Beadhouse* piece	23	14	28	10	675	45
1	9	1	7	*Tho. Freeman* 1 land	1	8	28	12	40	04
2	16	2	12	*John Weaver* 2 lands	2	14	28	12	77	22
1	16	1	14	*Vincent Wing* 1 land	1	15	30	12	53	37
4	16	4	12	The *Town* 3 lands	4	14	30	18	145	23
1	0	1	0	*John Weaver* 1 land	1	0	31	6	31	30
1	4	1	2	The *Town* 1 land	1	3	32	0	36	80

The second Furlong beginning West.

17	17	17	5	L. *Camden* 11 Lands	17	11	37	10	658	12
1	18	1	6	*Parsonage* 1 land	1	17	34	18	64	56
1	14	1	12	*Vincent Wing* 1 land	1	13	34	10	56	92
2	12	2	10	The *Town* 2 lands	2	11	34	10	87	97
1	11	1	11	L. *Camden* 1 land	1	11	34	10	53	47
1	10	1	8	*Tho. Freeman* 1 land	1	9	34	8	49	88
1	0	1	0	The *Town* 1 land	1	0	34	8	34	40

The *Beck*-Furlong begins West at *Brokenback.*

1	19	1	17	*Ionath. Barker* 1 Ley	1	18	32	12	61	94
2	0	1	18	*Vincent Wing* 1 ley	1	19	32	12	63	57
6	16	4	0	*James Digby* Esq; 3 l.	5	8	33	17	182	79
8	17	4	3	*Ionath. Barker* a piece	6	10	28	0	182	00
3	16	3	12	The *Town* 3 leys	3	14	26	12	98	42
1	14	1	12	*Vincent Wing* 1 ley	1	13	24	10	40	42

After this manner you are to proceed, from one Furlong to another, untill youhave finished your

Field-Book; which being done, you are next to make a particular of every Mans Arrable, Leys, and Meadow, severally, to which purpose, upon a fair sheet of Paper, you are to make so many Columnes, as there are Freeholders, every one whereof is to be subdivided into three, so will the first serve for Arrable, the second for Ley-ground, and the third and last for *Meadow*, if there be any: and if one sheet will not contain the whole, then may you take two, or three, or so many as you see convenient. Then turning to the Field-Book, I begin upon *Oldhams*-Hedge furlong, with 2 lands of *Mr. Samuel Hunts*, and write in the Particular, in its proper Column, under Arrable, 141 P. 40: then *Mr. Jonathan Barker* 3 lands, 172 P. 20: next *Mr. Samuel Hunt* 5 lands, 248 P. 16, which I place likewise under their names, and in their due place, and so I proceed till I have finished the Book; placing every *Mans* Arrable-land, Leys, and *Meadow*, in due order; which being performed, then make your *summa totalis*, as is done in the following Synopsis.

A Particular of all the Arrable, Leys, and Meadow-ground, in the Lordship of N. Luffenham, Com. Rutland.

Samuel Hunt.				Jonathan Barker.				Vincent Wing.				Bead-house.			
Arrable		Leys		Arrable		Leys.		Arrable		Leys.		Arrable		Leys.	
141	40	00	00	172	20	61	94	48	11	63	57	675	45	0	0
248	16	00	00			182	00	53	37	40	42				
								56	92						
389	56	00	00	172	20	243	94	158	40	103	99	675	45	00	00

Thomas Freeman				John Weaver.				The Town.				Lord Camden.			
Arrable		Leys		Arrable		Leys.		Arrable.		Leys.		Arrable.		Leys.	
40	04			77	22			145	23	98	42	658	12		
49	88			31	30			56	80			53	47		
								87	97						
89	92	00	00	100	52	00	00	270	00	90	42	711	59	00	00

Parsonage

Parſonage.		James Digby Eſqʒ	
Arable.	Leys.	Arable.	Leys.
64 56			182 79
64 56	00 00	00 00	182 79

After *this* manner you are to make a Particular of the whole Field, and not make your *ſumma totalis*, till all the Furlongs be inſered in the Particular: But this is a perfect Example, according to which you may effect the whole.

The next thing you are to do, is to take the Plot and generall Survey of the whole Lordſhip; according to the manner delivered in the former Chapters, and ſee if the ſumm of all the Particulars agree with the *Total*, then you may conclude the Work is exact, but moſt commonly the Particulars (if they be exactly taken) will ſomewhat exceed the generall Survey, eſpecially where the Lands lie high, as in *Leiceſterſhire*; and in this caſe, that both may agree, you are to reduce the ſumm of every *Mans* Particulars, anſwerable to the proportion of his Ground, which may ſpeedily be effected by the Golden-Rule: for, if in the whole Field, (which admit it be 1200 Acres) the Particulars exceed the generall Survey $3^{Ac.}$, or $480^{P.}$ what ſhall $20^{Ac.}$ exceed? the Anſwer will be $8^{P.}$, and ſo much I am to deduct out of the ſumm total of ſuch a *Mans* Particulars, according to which I am to Plot him $19^{Ac.}\ 3^{R.}\ 32^{P.}$, as is directed in the ſixth Book: But before I proceed to ſet out any Plots in the field, it is uſual in moſt places for the freeholders to chuſe Commiſſioners, who ſhall appoint in what part of the Fields every *Mans* Plot of land ſhall lie, where you are exactly to meaſure, and lay out the ſame, according to the quantity in your Particular. And laſtly, when all the Plots are ſet out, and corrected, if need be, you are (as often as it ſhall be required) to draw a Plot of the Town, Streets, Lanes, Houſe,

Homesteds, Woods, and all the old and new Inclosure; not forgetting to describe every River, Gutter, Water-course, and *Mills*, if any be, as also Trees, where they are standing, and that partly according to their number and quantity. Lastly, when you have drawn your whole work upon Paper, you may speedily draw out the same upon Vellome or Parchment, which being garnished with water colours of the best sort, will neatly shew the just proportion and Symmetry of the whole Mannour. But if you know not the way how to do it, then take these short directions.

Rub the backside of your Paper-plot all over with Black-lead, or Sallow-cole, then lay your skin of Vellome upon a smooth Table, and upon that lay the leaded side of your rough plot, which you are to fasten upon the vellome, at the corners, with Mouth-glew, then take a Bodkin, and therewith gently trace over all the lines within the said Plot, and whatsoever else you would express; then taking off the rough Plot, you shall see upon the Vellome, the perfect draught of your whole Work, wch you may beautifie at pleasure with neat Colours.

Before I conclude this Chapter, I shall speak something concerning Inclosure, by way of caveat, and advice to all such as proceed that way. And first I say, that the laying of mens land together in plots, and inclosing the same, is a thing (as I conceive) that in it self is very good, and profitable, provided it be but so performed, that there may be sufficient provision made for the poor, and no depopulation ensue. But we see the contrary in many places, & especially where a Lordship lies in the hands of two or three men, and then what follows (in such places)

but

but depopulation, for nothing (many times) will be allowed the poor Tenant, no not upon indifferent Rents, but the Lord of the Mannor (in moſt places I have ſeen) preſently ſets all his land upon a Rack-rent, & if ſome allowance be made to the poor Cottiers, at a little cheaper rate then ordinary, yet no ſooner, but when one man dies, the land is taken from the houſe, and the houſe immediately pulled down, & ſo at length many a Town is depopulated and comes to nothing, & there is no inhabitant left in the place, but (as our common proverb hath it) the Sheapherd and his Dog, whereas before it would contain two or three hundred people to live upon in good ſort and faſhion. But let us obſerve what follows theſe Depopulators; doth not the curſe of God purſue them to the heels? How many great ones of this Nation, after they have effected their evil deſignes in depopulating whole Lordſhips, have been ſuddenly taken away by death? others though they have raiſed their Eſtates, yet preſently come to nothing, whereby we ſee that of the Prophet verified. *Va vobis, qui conjungitis domum ad domum*: wo to them that joyn houſe to houſe, and lay land to land, till there be no place left for the Poor. And the wiſe man tells them *Prov.* 20. 16. *Qui opprimit tenuem, ut amplificet rem ſuam, & qui dat divitii, tantum ad egeſtatem deveniet.* And ſure I am that depopulation is a great ſinne, and highly provoking the Lord to wrath. Let me therefore admoniſh all (that go upon deſigns of this nature,) to be careful to make ſuch proviſion, that the Inhabitants of every Town and Village, where Incloſures are made, may have ſuch quantities of Land laid to their particular houſes, to be aſſured to them and ſuch as ſhall ſucceed

them for ever, and that ſuch proviſion and good orders may be taken, that Gods bleſſing may follow upon their juſt deſigns & undertakings. But I would not have you think that I here ſpeak againſt Incloſure in the leſt, but onely againſt depopulation, for I have ſeen and do daily ſee much inconveniency in many open and common Fields, where (Land lying intermixt) one man continually intrenches upon another, by plowing, and in their common, and ſo it may do well in ſuch places, eſpecially where all the Town are Freeholders, in which caſe, their land being laid out into ſeveral parts, and incloſed by it ſelf, all the inhabitants may the more fitly and commodiouſly injoy their own, and not be ſubject ſo continually to treſpaſs upon one another, as is uſual in common Fields. And beſides it would be a thing very good for all ſuch people, who have much Tillage, and little or no paſture, to lay down ſome of their land ground, and convert it into paſture, whereby keeping a greater ſtock of Cattel, they may be the better inabled to uphold their Tillage, which would be an inriching to them, as I have ſeen it verified in ſundry places of this nation, where by good manuring thereof, they finde more profit of one Acre, then they did of two before, and beſides (keeping more Stock, and better Deeries) they are better inabled to maintain their families. And ſurely that if the incloſure be no more, but for the better management and upholding of Tillage, it cannot be offenſive to the word of God, or deſtructive to the outward well-being of mankind, but will tend much to the good and wellfare of the nation. And thus much briefly touching Incloſure.

The end of the ſixth Book.

SCALÆ
Orthographico-metricæ, &c.
AN
Addition or Appendix
To the Art of
SURVEYING LAND,
OR,
Artificiall SCALES for the moſt accurate delineation and dimenſion of a *Land-Plat*. With an after-application of the like to the other moſt uſuall, uſefull Menſurations. And ſome diſcourſe beſide, convenient thereunto: And moreover, A new and curious way for diſcovering the Conent of any delineated *Plat* or *Plane*, without a *SCALE*, or any manner of meaſuring the ſame: only the *Scale* by which it was laid down being known.

WHen I firſt entred the Field by my ſelfe, for my improvement in the Inſtrumental exerciſe, or practice of Geometricall Survey (which thing firſt allure me to a love of, and delight in, the Mathematicks)

thematicks) from that ſmall, ſuperficiall inſight which not long before I had gotten therein from a young mathematicall Maſter in London, *(only in the meaſuring and plotting of two or three ſmall parcels of Ground, or Encloſures apart; but not together in any way or manner of connexion or complotment (as I may term it) or compleat Topographie, as at firſt I expected from him, he not being well experienced therein himſelf, as I found at laſt) who then as well as ſome other skilled in this Art, commended to me Mr.* Gunters *Chain for the beſt; more eſpecially for larger Grounds, as giving the lengths or diſtances in the Field wholly in Chains, that being made the Integer of meaſure, (the ſaid Chain being 4 poles or perches, and equally parted into* 100 *links, which he cals Centeſims; but which for brevity, we will here all along call Cents: and ſo the Chain called a decimall Chain) and thence the ſuperficiall content, immediately in a manner, in Acres, and decimall parts of an Acre, according to exact decimall accompt; without any notice firſt of perches, as all other Chains do: and ſo without the work of Diviſion ariſing or required therefrom: But no Scale proper or peculiar to this Chain did they uſe, or could they tell me, whereby to lay down a Plat, and ſo caſt up its content (as we commonly ſpeak) or meaſure its Area, immediately in chains, according to the true intent and nature thereof, in magnitude*

or

or proportion agreeable or equall to any common or plain perch-ſcale appointed: but only uſed thoſe ordinary ſcales with this Chain, like as with all other, by reſolving the chains into perches; or but at the fartheſt mentioned to me an ordinary diagonal ſcale (ſo called) as that of an inch, or the like, to an 100 *parts, for other meaſurings, and which my ſelf had imagined before: which I replied to them, could not regularly perform this work, and ſo not ſatisfie the thing neceſſarily required. Nor could I ever ſince meet with any Artiſt of this kind, that uſed, or ſeemed to know any other kind of ſcale beſides thoſe uſuall ones, or ever could I ſee any other ſort deſcribed or mentioned in any book of Survey: So that I have wondred that Mr.* Gunter, *who was ſo ingenious and induſtrious in the invention of Lines and Scales for other mathematicall uſes in generall, ſhould not invent one convenient or correſpondent in particular to his own Chain; which if he had done, he would undoubtedly have deſcribed it, or at leaſt, mentioned it therewith. So that to uſe thoſe common ſcales with this Chain, I found was to make it no other, or better, then any other Chain; as Mr* Ratſborns *is commonly made, which was the beſt before this, being ſimply of it ſelf, only the Pole or Perch divided into* 100 *equall parts or links, and ſo a kind of decimall chain alſo: and thereupon may indeed be ſtill counted*

more

more exquisite then this, as to the Field measure, or plain mensurall part only, but not so, as to the orthographical, topographical, or scalar part in generall; in regard it cannot so easily or conveniently, nor so generally admit of such a scale as this, which may give the 100th part of a perch exactly, as the curiosity of that Chain requires (no nor always the 10th part as it may fall out, according to the ordinary Diagonal Division, which he calls a Trime, and counts sufficient for ordinary measuring) for that the part of an inch denoting a perch upon the usuall scales, is for the most part so small, as that it will not very conveniently bear the diagonal (or figurate as I may term it) or artificiall decimal division (especially to an 100 parts) much less then the plain, simple, naturall, or vulgar, which will not well admit of above 4 parts in the largest of them that are nominated for this use (and even those but hardly too) to wit, the 10th part, and so the whole inch, 40 parts: what division, I pray, then shal one of those parts bear any way, so as to give any part of a perch, being made the scalar measure of a perch, in very large Plats indeed? (as I have heard some Surveyours say they have sometimes been enforced to do) but that perhaps you will answer, in such large Mensurations, they do not stand upon parts of a pole, but only whole ones, as deeming that very sufficient: And so they can but even guesse at the

4th

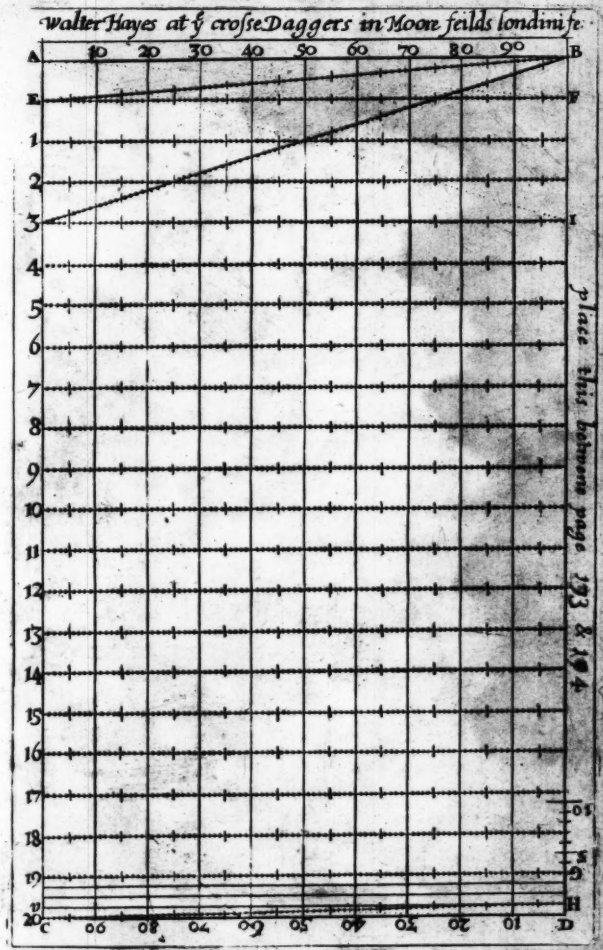
4th part of a Pole in many of their ſcales, and but at the 8th in moſt of them; and beyond, or beneath this laſt they commonly care not to go, as being their common partition of a perch: which as it wants very much, or is exceeding ſhort of that here handled, for the accurateneſs or exactneſs of meaſure, or the geometricall part; ſo likewiſe for the eaſineſs and readineſs in caſting up the ſuperficiall content, or the Arithmeticall part; as is well known to thoſe that are acquainted with the way and nature of decimall Numeration: Only that theſe vulgar parts taken upon the plain Scales may immediately be expreſſed in Decimals: but then however the practicer is tied wholly to thoſe very parts; whereas by our diagonall or artificiall Scale any other number of decimall parts is as eaſily and exactly taken, according to the juſt or true meaſure of a line, given or required. Nay rather, more exactly for the moſt part, than thoſe common parts can be from the common Scales. But how far we may make a ſhift to go in our diagoniall diviſion or manner of Scale, for Rathborn's Chain or Meaſure, I ſhall ſhew in the concluſion.

And hereupon betaking my ſelf to my own invention, I did ſoon hit upon this Diagonal kind of Scale for *Gunter's* Chain, being therefore in form of a Rectangle Parallelogram, (as here A B C D) the uppermoſt or top line (A B) ſerving chiefly for numbring the parts in the handſomeſt manner, and ſo the Scale rather in form of a *Trapezia*

(or

(or Trapezium, EBCD, as all other Diagonal Scales more properly are, or may be ſo conceived and made; or indeed more ſimply and naturally and moſt properly in it ſelf, of a Rectangle Triangle, as I ſhall ſhew afterward) and the breadth, or ſhorter ſide thereof (AB and CD) to be ſo much as may be conveniently divided into 100 parts for the links of the chain, with a ſmall ſpace beſides on either ſide, for the better taking off the chains which fall thereon, and for numbring the chains throughout the ſcale. And the length or longer ſide (AC and BD) to be ſo much as may conveniently anſwer to the extent of midling, or ordinary ſized Compaſſes, fitting for ſuch an uſe ordinarily (which may be nine or ten inches, or at moſt, a foot) and ſo the intire chains to be ſet down along that on both ſides equally, and numbers thereto on the left ſide (as on the line AC, which therefore I call the prime chain-line) and then lines to be drawn between them (being perpendicular, or rectangular to them, and ſo directly croſs or tranſverſe the Rule or Table, and parallel to the ends thereof (AB, CD) Then one line to be drawn between the ends or extremes of the two firſt or uppermoſt of thoſe direct tranſverſe lines (as here EB) and ſo obliquely tranſverſe the Rule, which therefore is commonly called a Diagonal line; and is, properly ſo here, as being the *Diagonal* of the rectangle Parallelogram (ABEF) and is the moſt notable line of all. And ſo the two extreme lines (AB or EF and CD) being divided as aforeſaid, a line drawn between each correſpondent part thereof (running perpendicularly, or rectangularly to thoſe lines, and ſo paral-

Walter Hayes at ye crosse Daggers in Moore feilds londini fe.



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UMI

parallel to the ſide lines (A C, B D) ſhall divide all the intermediate tranſverſes equally with them, and ſo the Diagonial proportionably (by *E.6.p.2.*) which therefore I call the link lines, as thoſe down right lines, the chain-lines. But to draw thoſe lines through every part of the other, upon the Scale viſibly, will be neither neceſſary nor convenient, by reaſon of the parvity of the parts; but only through every tenth part, and thoſe to be numbred accordingly in the top or head of the Scale, and the other intermediate parts to be noted with very ſmall ſtrokes, or onely pricks; but the fifths with ſomewhat longer ſtrokes will be convenient, as in our preſent Draught: which, they that liſt to affect ſo needles a nicety, may difference by the names or terms of primes and ſeconds, as in Maſter *Rathborns* Chain is done: and as ſome are pleaſed to divide all decimal fractions in general, that exceed the ſimple or primary denomination, into the ſeveral diſtinct denominate parts, or ſpecies uſed in the common aſtronomical (or ſexagenarie) accompt; whereas the ſame decimal fraction, be it never ſo large, requireth or needeth properly and naturally, but one denomination, according to the number of its places, as centeſms, milleſms, deci-milleſms, &c. and theſe not to be parted into the ſeveral ſpecies of primes, ſeconds, thirds, fourths, &c. unleſs it be for aſtronomical calculation in a decimal manner (which is the beſt) according to that of the ſexageſimal; and ſo which we may then (for diſtinction and brevity-ſake) call primes (or minutes abſolutely) ſeconds, thirds, &c. Inſtead of tenths, centeſms, milleſms, &c. But this by the way.

And

And lastly, to lay down any number of whole chains given, upon the topographical Table or Chart, is but onely to take them off the prime chain-line (A C, or E C) with compasses extended from the first divided transvers Line (at E) downward to the number given: but for chains and links together, one foot must be set upon the crossing of the proper Chain-line, and Link-line mutually (or upon the prick or stroke in the Link-line, where the Chain-line is supposed to pass; when the measure falls not on one of those lines ready drawn) answering to the number of Chains and Links measured, and the other extended to the Intersection of that Chain-line, and the *Diagonie*, or to the point or stroke on the Diagony answering to the same number of links: [Which Line may more specially be called by it self, the Link-line; the other, or direct transverses being in a sort, Chain-lines also, as being drawn to every Chain, and limiting the same throughout the breadth of the Scale, and so representing them in the centesimal partition: but the perpendicular or falling Lines be most properly Chain-lines, as having the scalar or uncial measure of the Chain set thereupon, and so the Chains intirely taken therefrom, which otherwise in a manner might be called also Link-lines, as dividing or severing the Links; though indeed there is no absolute necessity for any of these Lines beside the two outmost, but that small strokes or pricks might serve throughout; onely at every tenth part to make a larger, and at every fifth a little taller one then the rest, (as I noted before) but however these lines drawn throughout to every tenth part make the Scale more comely, especially

where

where the inch-measure of the chain is less, so as that the transverses fall nearer together.] And then to lay down (or take off from the Scale) any number of links given alone from the Chain, one foot or point of the Compasses must be set upon the uppermost transvers line, and the other upon the Diagonial, in that number of Links or cents, which distance shall be for the Links desired. And so for finding the Chain-measure of any Line of the Scale-plat required, as being yet unknown (as of the bases and perpendiculars of the Triangles into which the same is resolved, for finding of its areal content: or of any other line of distance desired in the Field) the said Line being taken in the Compasses, and one foot drawn or traced along the Diagony, and the other correspondently among the direct transverses to and fro, till both feet fall directly upon the very same cent in the Diagony and one of the transverses (if there happen to be any links beside whole chains, as most commonly there will, and very seldom otherwise) shall shew the measure of the same in Chains and Links, even upon that transvers alone, by the number on the left side of the Scale answering to it, for whole chains, and the number on the top noting the cents. But if that extent of the Compasses being so equally or evenly moved to and fro as aforesaid, exceed not the distance of the Diagonial, and the next or first divided transvers (E F) quite throughout; then the measure of the Line required will be Links only, or but part of a Chain; or but one compleat Chain at the most (as B F)

And thus is this Scale completed with one singular

diagonal line: and so might the common diagonal scales for more common or lesser Mensurations be also made (as that most usual and useful one of an Inch, for dividing the same into 100 *parts exactly) by drawing direct transverse lines through all the* 10 *parts of the Measure given to be divided, and then numbring these parts downward on the left side of the Rule or Scale, as here is done for chains, or integers (or units, as Mr.* Rathborn *called his) contrary to the usual way, where Diagonals are drawn through all the parts, being then upwards, and so the measure of the cents taken off from below, or the lower direct transverse, terminating there the measure divided, but which may aswel be numbred downwards on the right side, and then the said centesimal measure taken from above, or the upper direct transvers, terminating the divided measure there: (for both wayes give the same thing.) And this only for finding the centesimal parts: But for finding the integers and parts together, (as inches and cents joyntly) then the common way by diagonal or obliquely transvers lines through all the parts must stand, for the more conveniency in measuring (the breadth of the scale being also made* 10 *equal parts, and through every part a line drawn down the length of the Rule) the integers being iterated down the Rule from that which is diagonally divided, or the diagonal scale it self. But which yet may be more neatly done upon our manner of scale*

for

for Agrometrie (*or Agrimensure*) *or* Agrographie, *as I shall shew in the end.*

Nor can our scale be made with divers diagonal or obliquely transvers lines, and one direct transvers only, for the parts of the chain, unless the parts of an Inch (or of the plain perch-scale) representing the chain entirely, were so large, as might (being one entire line) be divided into 10 *parts so distinct, as that divers Diagonals might be drawn sufficiently asunder without confusion: (as is done in the ordinary diagonal scales to an inch, yea half an inch, but which cannot very well be done to a quarter) For then also in this kind of scale, a short transvers-line divided into* 10 *parts only, for the breadth thereof might suffice: and so it would be divided just as those common scales, to wit,* 10 *parts each way, for the length and breadth, and so give the centesimal parts of the chain accordingly.*

And so one such Diagonal line serving the turn alone (as in our present draught) and being the principal line of the scale, may well enough give it the Denomination of a Diagonal scale. Or being taken as the Hypotenuse (specially so called) of one of the equal rectangle Triangles (half the Parallelogram A B E F) in which the Scale simply and entirely of it self is concluded or comprised (as here E F B) being indeed the true compleat scale it self: but that the other direct transvers or parallel line (A B, and so the Parallelogram A B E F) is drawn

for the easier and exacter dividing or parting of the Diagony or Hypotenuse (E B) the same may as well give it the name of an hypotenusal scale: (For every Diagonal or per-angular line in a Figure may be term'd an hypotenusal, as being also an hypogonal or sub-angular line, especially being taken simply, or in respect of but one angle; every such line being generally an hypotenusal.) And so the Figure (whether Parallelogram or Triangle) constituting it, or the geometrical form or frame thereof and manner of division, may name it a figurate scale: as the arithmetical partition may denominate it a decimal scale: And so which at last here for its accurateness or perfectness therefrom, above all other scales for our present use or purpose in particular, may (not improperly or unfitly) be called the Orthographical or rather Acribographical scale (the first of these terms in a mathematical sence implying also Plotting it self, or Architectonically the same as Ichnographical) or rather in one word as it were, for the making first, and then measuring of a Plat, (both which one and the same scale performs as one thing in a manner) the orthographico-metrical or acribographico-metrical scale. And then for its use here in general, the Agrographico-metrical, Pedographico-metrical, or Topographico-metrical scale.

Now

Now as to the magnitude of our Chain-Scale here delineated, it is fitted in proportion to a plain Perch-ſcale of 16 in the inch, which Surveyors have uſually counted the moſt indifferent and reaſonable for plotting of midling Grounds or Incloſures, ſuch as are for the moſt part in the Counties near *London*: And ſo four of thoſe parts repreſenting four poles or perches, do make or conſtitute *Mr. Gunters* chain upon our Scale, which is juſt a quarter of an Inch; whereby the whole chains are ſet down the left ſide of the Scale and numbred from E, the connexion of the Diagony and the firſt divided direct tranſvers, ſo far as (or farther than) here was needful, for the length of the Scale; (though that matters not in this place, whether it be more or leſs, conſidering that the Scale it ſelf is comprehended in either of the aforeſaid figures alone, as I juſt now ſhewed.) And the divided breadth A B or E F, for the centeſimal links was made here by me juſt three Inches, which I think is as narrow as can conveniently be; [Though the Cutter or Graver hereof in Braſs, hath by chance made it ſomewhat broader, whereas he was minded once to make it narrower; by name, Maſter *Walter Hayes*, dwelling at the two *Croſs-Daggers* by the *Popes-head-Tavern*, about the middle of *Moor-fields-London*, where he maketh all manner of Mathematick Inſtruments very accurately in Braſs, Silver, and Wood, for what uſe ſoever, as ſhall be deſired of him; And to whom ſpecially I recommend Surveyors for the making of this kind of Scale, he being the only Inſtrument-maker, whom I have made acquainted therewith.] And if it were made for uſe, half an

inch broader, especially in wood, it would be so much the better for the interstinction of the parts, and considering withal that the length needs never to be much, and so it will not be troublesome to carry; though a line of 2 ½ or but 2 Inches may be divided so by it self simply into 100 parts (as I have done in my *Tactometria*, in the Line there drawn for the quadratic dimension (or squaring) of a *Pentagon* by its side, according to the prime or natural Line of measure there first laid down for exemplary demonstration, and so the same but very little above two Inches (only two cents) but which for this kind of Scale will be too little, because then the parts or divisions being so very small, it will be impossible to take off the true measure of a line given in the Plot to be measured by the Scale, to one part or cent thereof; for that in three or four of the parts next together, the difference of length, or of measure, will not be discernible by the Compasses. But yet however as to this very point, it may be objected by an intelligent artist, that whether the breadth of the Scale (or length of the line of parts, direct or oblique) be more or less, it makes no matter, so that it may admit or obtain a due or distinct division of the parts: For the greater it is, the lower doth the Diagonal line fall, or is more depressed, and inclined to the adjacent or conterminous transvers; and so less oblique, making a lesser Angle with the same, as here at E: And the lesser that is, the higher is the Diagonie raised above the said transvers, and so more oblique, making a greater angle therewith: And so the nature and property of this Line (or of this kind of Scale) is in no wise altered thereby (as some

ſome perhaps may ignorantly imagine) but the ſame meaſure is evermore produced therefrom proportionably: for each part or partition-point thereof progreſſively is raiſed alike in proportion both wayes; to wit, the former in a greater ſpace, and the latter in a leſſer. And this poſition of the Diagony will be altered likewiſe, as the meaſure given to be divided in this manner, ſhall be greater or leſſer: for the greater it is, the higher will the Diagony riſe, and the leſſer it is, the lower will the Diagony fall, upon the ſame Scale-breadth, or in reſpect of the ſame direct tranſvers.

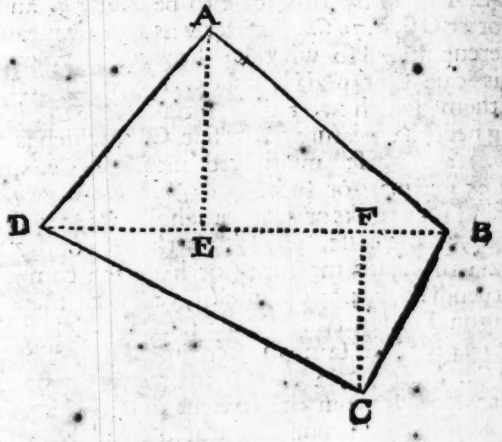
Now to lay down here the platform of a parcel of Land whereby to ſhew more particularly the uſe of this Scale with the Chain, I may think it wholly needleſs, as to any ingenious, intelligent practicer, the directions already given being very ſufficient: But for fuller inſtruction and ſatisfaction to ſuch as are not yet well acquainted with the nature of diagonal ſcales (for whoſe ſakes I have been more large in diſcourſing thereof then otherwiſe I would; and alſo becauſe I have not met with any one that hath given the grounds or reaſons thereof; which therefore I have here done out of mine own apprehenſions and conceptions of the ſame) nor of Mr. Gunters *Chain, in the true uſe thereof (as I dare ſay very few vulgar Surveyours are; and none at all with this agrometrical or agrographical kind of ſcale, that I could ever yet find, as I noted at firſt, except one or other to whom my ſelf have told it; though ſome other may have happened upon the ſame for ought I know) I think*

it not amiſs, but rather meet ſo to do; but which ſhall only be in one Trapezial Plat of ground, as being ſufficient for underſtanding the way in any Land-plat whatſoever, ſeeing that the readieſt way of caſting up, or meaſuring the area of any Plot, is by dividing it firſt into as many Trapezies as it will admit (and which way Mr. Rathborn *himſelf commended to us) and then each Trapezia into 2 triangles, by drawing a diagonal line therein the convenienteſt way for the falling of perpendiculars from the oppoſite angles of theſe two triangles upon the ſame, being thereby the common baſe to them both: Which lines then being meaſured by the ſcale, and the aggregate of the 2 perpendiculars multiplied in the whole Baſe, half the product ſhall be the area of the whole Trapezia (as if it were but one triangle) in perch-meaſure, by the common way, and in chain-meaſure by Mr.* Gunters *way: which laſt will be then, in a manner, acre-meaſure, as I noted in the beginning (or the half of one with the whole of the other, gives the ſame) And which are to be reduced into acre-meaſure by their reſpective terms of diviſion for that purpoſe,* viz. *160 in the former, and 10 in the latter: but if there be no halving at all done before-hand, then the double of theſe terms muſt be taken,* viz. *320 and 20, as the terms of mediation; becauſe without this, is produced the content of a rectangle Parallelogram or Oblong, double to the Trapezia, or Triangle (by E. 1. p. 41.) and which then*

muſt

must be halved at last; (unless this were done by our artificial dimension of Triangles in general, delivered in Tactometria, *which I shall a little more speak of at last.) And when there is an odd Triangle remaining above the Trapezies, that must be measured by it self, and then cast to them.*

As let this Trapezial figure A B C D, be the plot of a smal Enclosure, whose sides are supposed to be measured exactly by Mr *Gunters* Chain, & laid down by our Diagonal Scale here delineated (or so many of them only as were needful to be measured for enclo-

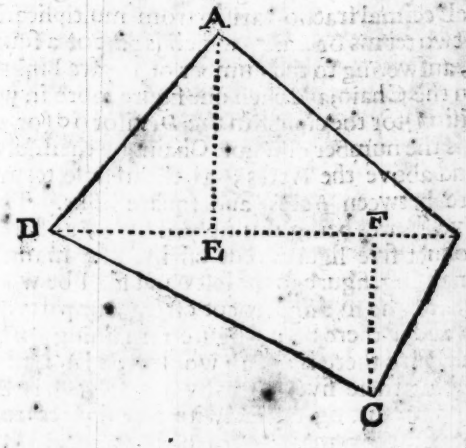


sing the same, upon the *Orthographical*, *Topographical*, or *Agrographical* Table, (suppose the PLAINE TABLE,

TABLE in its plain, simple or natural capacity, as being the exactest Instrument for this purpose) and which need be but one of them, the longest is the best which is C D (or none of the sides at all, but rather one Diagonal line only, and that the longer, as the better, being D B, for either way does the work by two stations, or observations taken at the ends of either line, the line measured being the stationary distance) And this Trapezial Plat divided into the two triangles D A B, D C B, by the said longer Diagonal D B, which I measuring finde to be 9 Chains and 81 links or cents precisely, (and which by Decimal notation may more briefly be expressed 9.81 *Ch.* and so the rest) And then the longer perpendicular A E, I finde by this Scale to be 4.87 *Ch.* and the shorter C F, 3.79 *Ch.* (as neerly as can be measured thereupon: and so wil these three lines be found, if this Scale & Trapezia be cut exactly to my draughts of them) which two together make 8.66 *Ch.* (coming neer the measure of the side C D, which is 8.72 *Ch.*) and these multiplyed into 9.81 *Ch.* make 84.9546 square or superficial *Ch.* (*viz.* 84 *Ch.* and 9546 square links or cents, or wholly 849546 square links) whose halfe, 42.4773, is the area of the Trapezia in Chain-measure (or halfe the compound perpendicular, 4.33 *Ch.* multiplyed with the whole diagonal 9.81 produceth the same) which divided by 10 gives the same in Acre measure. For that 10 *Ch.* in length, and 1 *Ch.* in breadth do make an Acre. Whereupon the content of a Rectangle or Oblong plat of ground measured by this Chain, is had immediately in Acre-measure, by dividing the product of the length and breadth by 10 only (which is no more then as by 1, and so no work of

Di-

Diviſion at all, but only an abſciſſion of the Cipher and the laſt figure of the integral part of the product for the ſame) And ſo of a Triangle, by dividing the product of its Baſe and Perpendicular by 20, (which is but as mediation or bipartition, by the abſciſſion of the cypher, and of the like figure in the



Product for it) And the like of a *Trapezium*, conſidered only as one Triangle as aforeſaid. And therefore to bring the ſquare Chain-meaſure here firſt had, into Acre meaſure, is no more then to cut off therefrom five figures on the right hand; for thoſe that are left on the left hand ſhall ſignifie entire Acres (and if there be none at all left, then there is no whole Acre) and the five figures ſo cut off, ſhall be

be a Decimal part of an Acre in Chains and Links, or Links alone, according to the number of ſquare Links in an Acre: (for that the meaſure may be reckoned at firſt in Links only, without the diſtinction of Chains and Links, it coming all to one paſſe, according to what I expreſſed even now in the ſuſuperficial content of this Trapezia) Or firſt (which comes to the ſame) cutting off but four figures for the due Decimal fraction ariſen from multiplication of the two terms or lines, which is part of a ſquare Chain, anſwering to the number of ſquare Links or cents in the Chain; and then one figure more in way of Diviſion, for the cipher in the *Diviſor* 10 (or 20) which is the number of whole Chains by themſelves over and above the Acres, as the middle term of meaſure between Acres and ſquare links. Then theſe five figures being multiplyed by 4, and from the product five figures cut off in like manner, the remaining figure to the left hand ſhall be whole Roods, and the five figures cut off ſhall be parts of a Rood (and if there be no figure remaining on the left hand, then there is not an whole Rood.) Laſtly, multiplying theſe five figures by 40, (which is but as by 4) and cutting off likewiſe five figures from the product, the remainder to the left hand ſhall be the number of ſquare or ſuperficial Perches, and thoſe cut off ſhall be parts of a Perch; (and if no figure remain on the left hand, then there is no whole Perch) As in this our demonſtrative Example,

A. 4|2.4773
4 *r.*
R. 0|99092
410 *p.*
P. 39163680 *Which comes very neer to a Rood.*

Now to apply this kind of Scale to Mr. *Rathborns* chain, or measure, so far as may conveniently be done; (which wil make the most accurate Agrography, and Agrometry, (or in one word, Agrographimetry) it must here be noted, that if the parts of an inch (or of a plain scale) for *Mr. Gunters* chain may, as one intire line, be distinctly divided into 4 such parts (for 4 perches) or the part of an inch for a perch, be so large, as that transvers-lines may be drawn directly to each part or perch, and a Diagonal-line betweeen the two next of them without confusion (as in this Scale is done to the chain-parts for *Mr Gunter*) and so divided all together into 100 parts: then will it affoord *Mr. Rathborns* measure (in the simple Pole-chain, and its cents, which may be called the simple, or natural Chain, or *Measure*) as exactly as the other doth *Mr. Gunters* (by the four-pole-chain, and its cents; which may be termed the compound, or artificial chain or measure:) As in our present Draught, the fourth part of an inch being the measure of *Mr. Gunters* chain (from the sixteenth part, the measure of *Mr. Rathborns*, as one Pole) and divided into four equal parts; which may be begun at the same end of the Rule upon the right side, and so the

the Diagonal line drawn backward, or contrariwise to the other (E B) and the poles numbred down the same side B D, &c. But better (to avoid some small confusion, which may happen that way to the unskilful, by the Diagonal line with the other Scale, and which therefore I would not here delineate, though it would be as nothing, if the said Diagonal be neatly drawn and divided; and so that seems to me the neater way) at the other end of the Rule (as here for demonstration-sake) in the last oblong partition or chain part, D 20 G 19, divided into four parts, for four perches, and lines drawn to each part parallel, and the Diagonal between the two outmost of them, from H to C, viz. H C or H 20, (that being now as the head or top of the Scalar Rule, and so the same to be turned and holden the contrary way to the former Scale) and these divided together by the former division into 100 parts, is the form or fabrick of this Scale for *Rathborn*. Or which simply of it self is contained in those two uppermost parallel transverses and the Diagony, or the first parallelogrammal pole-partition D C H a, or onely in the rectangle triangle H C a (being half thereof) but more fully and plainly, for taking the Poles and cents together, in that and the next transvers or pole-parallel under it, at which the accompt of the whole perches begins. And which being continued the length of the Rule, and figured or numbred on the line D B, directly to F, (which therefore I may call the prime Pole-line, as I did A C, the prime Chain-line, in the other) and which need not so much, nor conveniently can be, to every pole (they falling so near together) as in the other

other Scale to every Chain; but to every fifth or tenth, and so run on by tens, as in the plain Scales is done, and as here I have begun to the first ten, from H, the point of beginning: and the Cents numbred also by tens in a row by themselves on the line D C, directly from D to C, the contrary way to the former. Then will this Scale be likewise fitted to *Rathborns* measure; the Poles and Cents together being taken off the respective transvers lines and the Diagony, just as the Chains and Cents together in the other for *Gunters* measure: and the Cents alone from the first divided polar transvers H *a*, and the Diagony H C together, as in that, from the first Catenal transvers E F, and the Diagony E B together: and so the lines drawn in the Plot for finding its Area, or of any distance therein desired, immediately in pole-measure, being measured thereupon accordingly. As in the foregoing Trapezia, measured also most accurately by *Rathborns* Chain, and plotted by this Diagonal Pole-scale, I measuring the Diagonal line D B with Compasses thereupon, do find it to be 39 perches and 24 cents, (or more briefly 39. 24. *p.* or as he calls them, 39 units, 2 primes 4 seconds) falling between the tenth figured chain-part or transvers parallel (for *Gunter*) and the polar Diagonal H C, or H 20 (for *Rathborn*, which answer exactly to 9. 81. *Ch.* of *Gunter*,) And the greater perpendic. A E I find thereupon, 19 48. *p.* between the fifteenth chain-part, and the Diagony H C (answering directly to 4. 87. *ch.*) and the lesser perpend. C F 15. 16. *p.* between the sixteenth chain-parallel, and the said Diagony *H C* (answering precisely to 3. 79. *ch.*) which two joyntly, 34. 64. *p.* and the

Diagonal

Diagonal 39. 24. *p.* multiplied together, do produce 1359. 2736 ſquare or ſuperficial perches for the double Area of the Trapezia; which divided by 320 (that is as by 32) gives the true Area thereof in Acres, 4. 24773, exactly agreeing with the meaſure by Mr. *Gunters* Chain. Or half the product, 679. 6368. divided by 160 (which is but as by 16) yields the ſame. And ſo the fraction is valued, or reſolved into the common known parts of Acre-meaſure, as before. For here are the ſame five figures to be firſt cut off; to wit, four for the due fraction from Multiplication, anſwering to the number of ſquare cents in a Pole-ſquare; and then one more for the Cipher in the due Diviſour, which with the ciphers in the number of ſquare cents aforeſaid (being then the number of ciphers in the cents of ten poles ſquare, and which is the number of *Mr Gunters* cents in an whole acre) and the two figures of the Diviſour, do together make the number of ſquare pole-cents in an acre, which is 16 times that of *Mr Gunter*. (For here alſo may the meaſure be firſt reckoned wholly in cents, without any note or point of interſtinction, as I declared before for *Mr Gunters*; and ſo four figures cut off from the right hand in the ſuperficial meaſure hereof, leaves on the left, the whole perches, as in *Gunters* meaſure it doth whole chains.) So that the ſimple or natural meaſure from *Rathborn* is to the compound or artificial from *Gunter*, figurately or ſuperficially, ſedecuple, as it is ſimply or lineally, quadruple, in reſpect of quantity diſcrete or arithmetical; and this for the converſion of the firſt meaſure into the ſecond, (or deduction of the ſecond from the firſt) whereas elſe, in regard of quantity

quantity continual or geometrical, it is the ſub-contrary thereof: For that *Gunters* chain made artificially the integer or unit, or principle of Land-meaſure (for the greater compendiouſneſs and expeditenes in the work) being compared with *Rathborns*, taken ſimply as aforeſaid, as naturally the unit or integer, is quadruple the ſame; and ſo the ſuperficiary or figurate meaſure of that is to the like meaſure of this, ſedecuple, (which is the proportion duplicate or quadrate.) So that *Gunters* meaſure is reduced to *Rathborns* (or the artifical to the natural) ſimply or lineally, by Quadruplation, and figurately or ſuperficiarily by the Quadruple or Quadrate of that, to wit, Sedecuplation, and is deduced therefrom (or *Rathborns* is converted into *Gunters*) by the ſub-contrary or ſub-proportion, to wit, Quadripartition and Sedecipartition, or deniſenari-diviſion: though in the concluſion of all they both concur in the ſame common accompt of acres, roods and perches, to a title.

And thus are theſe ſcales for both the meaſures made together one within the other, as it were one ſcale. Then on the other face or plane of the Rule may very commodiouſly be made the like to ſome other uſual proportion: but which above or beyond this here laid down, arithmetically, or beneath it Geometrically, will for *Rathborns* meaſure be very nice, in regard the tranſvers parallels to be drawn to every pole-part will fall ſo near together, and then the Diagonal line between them ſo very flat and low, or ſo inclined to them, that a good part thereof will be even united therewith, and thereby will be very obſcure towards the ends, ſeeing

ing that in this very proportion or draught, it is not there so very clear or distinct therefrom. But yet however to the 20th or 24th part of an Inch I find it may reasonably or prety handsomely hold out, if it be neatly and handsomly drawn indeed: and which may be the better done, if the Diagonal Line be not drawn between two of the direct transverses or Pole-parallels, as the Diagony of a right-angled Parallelogram, but uppermost of all, as the Hypotenuse of a Right-angled Triangle, constituting the scale simply, naturally, or primitively, as before I have shewed; for so it will be obscure only about one end. And therefore if the chain-measure of our present scale for *Gunter* be divided into 5 parts, and lines drawn thereunto as in the other Scales, then will it be a pole-scale for *Rathborns* division, to 20 in the Inch; and it into 6 parts, then will it be the like scale to 24 in the Inch.

And here I may at last mention the artificial measure in my Tactometry, for Triangles in general; in casting up the content of a land-plat: (which I hinted before) whereby the base and perpendicle of any Triangle being multiplied wholly together, the product becomes the area thereof: and so consequently of any Trapezie, taken as one triangle, by one diagonal line and the compound perpendicular, as aforesaid: though this may seem a way more of art than use (as I have there said) it saving only the work of dimidiation. But however to this end, the Measure here (as simply and naturally the Pole or Perch) must be augmented to 0.41 *of the same (or more compleatly,* 0.414) *it being*

being the artificial additament thereof as divided into 1000 *parts) and ſo will be artificially* 1.41 *p. inſtead of the Pole it ſelf, according to the arithmetical index, exponent, or characteriſtick, of the compound artificial line of meaſure in general for this purpoſe, there ſet down, or its quantity diſcrete: which then as one entire line muſt be divided in like manner: And then the ſcale-meaſure of the Pole muſt be augmented accordingly; which in our preſent example being* $\frac{1}{16}$ *inch, is here exactly divided into* 100 *parts,* [*and ſo* $\frac{1}{10}$ *of the ſame into* 10 *parts: that is, the* 160*th part of an inch into* 10 *parts:* viz. $\frac{1}{10}$ *of* $\frac{1}{16}$ *: So that here may be had* $\frac{1}{10}$ *of* $\frac{1}{10}$ *of* $\frac{1}{16}$*, that is,* $\frac{1}{100}$ *of* $\frac{1}{16}$ *: to wit, the* 1600th *part of an inch upon this particular ſcale.*] *And ſo from thence wil the artificial perch upon the ſcale be duly ſet off: and which then as one ſimple line muſt be divided diagonally, like as the original meaſure it ſelf, for the artificial ſcale, or the ſcale of the artificial, ſuppoſititious, or ſubdititious Perch, to be uſed as the other ſcale. And then for* Gunter's *Chain, that alſo muſt be produced or prolonged anſwerably, and ſo made* 1.41 *ch.* (*or* 1.414 *ch.*) *which wil then be a more artificial, compound Chain than before, being taken entirely, and divided as that, for the ſecondary or ſubſtitutive Chain. And ſo the ſcale-meaſure of the primary or true Chain muſt be protracted correſpondently; and then as one ſimple line, divided like that, for the more artificial Scale: which*

meaſure being here made $\frac{1}{4}$ *Inch, is in our preſent Scale divided really into* 100 *parts* [*and ſo* $\frac{1}{10}$ *thereof into* 10 *parts; which is, the* 40th *part of an Inch into* 10 *parts;* viz. $\frac{1}{10}$ *of* $\frac{1}{40}$; *and ſo may be taken* $\frac{1}{10}$ *of* $\frac{1}{10}$ *of* $\frac{1}{4}$, *that is the* 400 *part of an Inch; and which Scale then may alſo ſerve for* Rathborns *chain (or Tole-meaſure) to* $\frac{1}{40}$ *of an Inch, as to his primes only, (accounted commonly ſufficient for more ordinary meaſuring, as chiefly in larger lands) in the firſt Decimal partition or Denarie of parts of this very ſcale; which in the centeſimal perch-ſcales aforeſaid are taken off through the whole breadth of the ſame upon the lines of Tens: but elſe a ſhort line of ten parts only, for the breadth of the ſcale, ſufficeth for theſe, as in the common Diagonal Scales. And ſo may four ſuch ſeveral Scales be conveniently made upon a Flat Ruler, of* $\frac{1}{5}$ *or* $\frac{1}{4}$ *of an Inch broad, and a foot long, that is, two on a ſide, being begun beſt at the ends thereof, & ſo drawn out to the middle: or* 8 *ſuch upon a ſquare Rular of that breadth every way, and length, to ſo many ſeveral proportions.*] *From which therefore the artificial meaſure of the Chain upon the ſcale, or this ſecond ſcale-meaſure thereof, will be exactly taken. Now the proportion between the prime or natural meaſure and the ſecond or artificial, for this operation in general, I noted there in my Tactometry, to be briefly, as* 1. *to* .7071: *but which more largely for the more accuratneſs, will be* .70710678, *though the other be ſufficient for this preſent, or any other*

ordinary

ordinary menſuration in general. [And is $\sqrt{\frac{1}{2}}$, viz. $\frac{\sqrt{2}}{2}$, the artificial line of Meaſure it ſelf in generall being $\sqrt{2}$: between which 1 is the Mean proportional or geometrical (or the Meſologic, as I may for brevity name it) both radically and quadratically; that is, in the Ratio dupla & quadrupla: or is exactly ſo between dupla and ſubdupla; to which the Mean arithmetical or ſimple (or the Meſologiſtic, Meſarithmetic, or Meſarithm, as I may moſt briefly term it) is the quantity of Seſqui-quarta, which is potentially that great Reaſon of Extremes and Mean, (called the admirable and Divine Proportion, for its excellency above all other, and the Proportional Section, or Section by Extremes and Mean, it conſiſting of three terms in continual proportion, according to E. 6. d. 3. and ſo E. 7. d. 26. and p. 20.) and admits of an univerſal Analogiſm, or Epilogiſm, whereby to obtain immediately its parts, even from unity it ſelf, in a Decimal manner, and therefore moſt expedite and exact; (as I have expreſſed the ſame in my Tactometry, among the Proportions of a Pentagon, in the Diameter or Perpendicle thereof, as being cut by the Hypotenuſe, Hypogonie, or Diagonie of the ſame, according to extreme and mean Reaſon (by E. 16. p. 2.) and which work firſt of all diſcovered to me the ſame, having not met therewith before to my remembrance, viz. Of the Whole to its greater part, portion, or ſegment (which is the Meſologic and greater

Apotome (*by* E. 13. p. 6.). *as* 1. *to* .618034 (*or more largely to the next convenient Section or ſtop, amounting to a Denarie*, .6180339887; *being* $\sqrt{\frac{5}{4}} - \frac{1}{2}$.) *and ſo to the leſſer* (*being onely the Reſidual of that to the* Whole, *or the leſſer* Apotome) *as* 1. *to* .381966 *completely*: (*but which for ſmall quantities to be thus proportioned or parted, may be only*. 618 *and*. 382.) *Which in terms abſolute or rational, I apprehended to be very nearly as* 5 *to* 3 *and* 2; *and ſo the greater part to the leſſer, nearly as* 3 *to* 2, Seſqui-alter: *as I have firſt ſhewed in a certain private Geometrical Exercitation of mine in Latine, occaſioned by a certain Probleme publickly propoſed: and which terms may ſufficiently ſerve for this proportional Section in an ordinary or mechanical manner, where a line is required thus to be cut in any geometrical Figure, or ſimply by it ſelf. Which things I thought might not be altogether amiſs, or out of the way, here to be inſerted.*]

And again as to the foreſaid artificial line of meaſure, I ſhewed alſo in that book, the ſame to be the Line for meaſuring a Square by its Diagony, to wit, for making the Diagony equal in act, and ſo in power, to the ſide Arithmetically, which elſe in the latter acception, is Geometrically, naturally or really, double thereto (*according to* E. 1. p. 47. & E. 6. p. 31.) *and thence is the Square circumſcribed to a circle, naturally double the Square inſcribed: the proportion here*

here laid down being that of the Diameter to the ſide of the inſcribed Square, viz. *of the Diagony of a Square to the ſide, as I noted alſo in* Tactometria. *From which proportion the Diagonal line of the foregoing Trapezie, in* Rathborns *meaſure* (39. 24. p.) *will be upon the artificial Scale peculiar thereunto*, 27. 75. *and the greater perpendic.* (19. 48. p.) *will be* 13. 77; *and the leſſer* (16. 16 p.) 10. 72: *which two together*, 24. 49, *being multiplied into* 27. 75, *make the area*, 679. 5975. *ſq. or ſuperf. perches; which wants of the true meaſure* (679. 6368. p.) *but* 393 *ſq. pole-cents, or* 393 *parts of* 10000; *and which according to the common accompt, is but about* $\frac{1}{25}$ *of a ſq. perch. And ſo the ſaid Diagonal in Mr.* Gunters *meaſure* (9. 81. ch.) *will be by the proper reſpective artificial Scale*, 6. 94; *and the longer perpendicular* (4. 87. ch.) *will be* 3. 44; *and the ſhorter* (3. 79. ch.) 2. 68: *which two joyntly* 6. 12, *multiplied with* 6. 94, *produce* 42. 4728 *ſq.* ch. *for the totall Trapezie, wanting of the true meaſure* (42. 4773 ch. *or* 4 *ac.* 2 ch. 4773 *cents or links, or* 4 *ac.* 24773 *ſq. cents, or moſt briefly* 4. 24773 *ac.*) *only* 45 *ſq. cents, or* 45 *of* 10000. *which differences between the true meaſure and the artificial in the ſuperfic. content, are as nothing.*

And laſtly, to apply this very kind of Scale to other Menſurations, it is to be noted, that as in our preſent draught, the 16th part of an Inch for the Pole, is divided exactly into 100 parts, and the 4th part for *Gunters* chain: (as I mentioned even now)

So likewise is the whole Inch here divided, in the rectangle Parallelogram A B 3, 1 (being 4 chain-parts) or only in the rectangle Triangle 3 1 B; by which its cents are taken off from the direct transvers-line 3 1, (the base of the Triangle) and the oblique transvers, or diagonal line 3 B (the Hypotenuse; the Inch it self B I, being the perpendicle) So that here is a complete Diagonal or hypotennsal Scale of an Inch to 100 parts, in the said Triangle alone; which serves for measuring any thing immediately in Inch-measure, especially being made near the top of the Rule, as may be, and that made longer, so as may be taken the measure in Inches and cents together, so far as the length of the Rule will give way. And if the Inch A 3 and B I, were divided equally into 10 parts, and then Diagonal or transvers lines drawn to each part obliquely opposite, after the usual manner; and so obliquely parallel: or only to each part directly, evenly or exactly opposite, and so directly parallel; and one Diagonal line between the two uppermost of them (as in the Scales for the pole and chain) and divided together with those lines for Land-measure; then would the Inch be as exactly divided into 1000 parts. But neither of these can conveniently be made with the scale for *Rathborns* chain, by reason of the polar parallels or transverses falling so near together, which would make a great confusion: Nor the latter together with that for *Gunters* chain, unless the scale-measure of this chain were the whole Inch (which never is) or be such apo rtion thereof as may be divided so into equal parts, that 10 of them may make the just Inch; as ½ for 4 parts of 8 (which never is)

or

or $\frac{2}{5}$ for 4 of 10 (which very ſeldom is uſed, as being the largeſt ſize of a plain ſcale in nomination) or $\frac{1}{5}$ for 4 of 20, or $\frac{1}{10}$ for 4 of 40 (in which laſt the whole Inch will be juſt 10 chain-parts) or elſe the tranſverſe parallels be drawn to the 10 parts of the Inch obliquely or diagonally, & not directly or Orthogonally: or otherwiſe both theſe Inch-ſcales to be made alone at the top of the Rule in the firſt place. And if the Rule be made to a Foot in length, then may the Foot be divided into 100 parts here like as the Inch: and into 1000 parts, as is directed here for the Inch: and into 10000 parts accordingly, if it be divided into 100 parts ſimply, or at length: and then will it alſo be divided into 1000 parts, if the tranſvers or Diagonal parts be only 10. By which Foot-ſcales will the meaſure of any thing be had immediately and moſt accurately in Foot-meaſure. And thus may this kind of Scale be completed for all uſual menſurations, as it were one general ſcale; which therefore may be called Pantometrical; as for the exactneſs or exquiſitnes above all other for meaſuring, it may be termed orthometrical, or rather acribometrical.

And next may be noted as an additament or appendicle to our Plot-ſcale, for the convenienter carrying and uſing thereof, a ſmall Semi-circle, to be cut out of the matter or ſtuff whereof 'tis made, at one end or ſhorter ſide of the ſame, and a little hole made in the middle of it, for a ſmall ſtring to hang it by at ones girdle, or other thing about the waiſt, or at a claſp on the left ſide (which wilbe beſt, except

cept for thoſe that be left-handed) *and indeed the lower end wilbe the better, that ſo the head or top of the Scale* (*or the diagonal end*) *hanging loweſt, the Scale may be more readily uſed, without turning it ſtil about: for to hold it with the diagonal line next to one, cannot be ſo convenient or ready for uſe. And therefore if the Scale for both* Gunter's *and* Rathborn's *meaſure be made together, it will be beſt alſo in this very reſpect, to have their diagonal lines, or beginnings, at one and the ſame end of the Rule, according to my firſt deſcription of that for* Rathborn. *But they may be alſo conveniently made upon the broad Ruler, with ſights for the* Plain-Table, *in the room of the ſeveral plain ſcales there uſually drawn; and that ſomewhat narrower than here I have done, if it ſhall be deſired.*

I dare not adviſe the addition of a large ſemicircle any way to this Scale, whereby to make it a complete Protractor (*or rather Contractor*) *for fear it ſhould be too comberſom or troubleſome for carriage and general uſe: But otherwiſe inſtead thereof, to have a line of Chords on each longer edge, for protracting of angles* (*as they commonly ſpeak*) *or for* Goniometry, *or Angle-meaſure* (*as I may term it*) *where the Survey is performed by a circular or gradual Inſtrument, wilbe* (*I think*) *very convenient & commodious.*

So ſoon as I had deviſed this manner of Scale for Gunters *Chain, I found ſuch marvellous con-*

tent

tent and delight therein from the exactneſs and eaſi-neſs in working, that I ſtraightway communicated the ſame to a very ancient and able Surveyour dwelling in the Countrey, about four miles from the houſe of an Uncle of mine where I then was, and who then firſt tried me in this practice, in the meaſuring & plotting of ſome Incloſures lying together to his houſe, and of the garden and yards, to make a compleat plat-form thereof; as alſo of ſome other fields a-part (which was in the year 1637*) All which had been done by this Surveyour ſome years before, for another perſon of greater quality, who was owner thereof, to wit, the Earl of* Norwich, *dwelling at* Waltham-Abbey *in* Eſſex*: who had drawn him from his more profitable emploiment in the Fen-countries, which he had long uſed, to meaſure and plot all his Lands hereabout: and ſo alwaies after here detain'd him to his great loſs and diſadvan-tage, upon promiſe of great reward. And who forth-with did thereupon himſelf make the like Scale in wood, and in the ſame proportion of a plain perch-ſcale that my ſelf then uſed, being that which I have here drawn and deſcribed: he buying then Mr.* Gunter's *Chain with all readineſs and joyfulneſs upon my ſpecial commendation thereof, which before he was not acquainted with, nor with any other of his works, till that I now told him thereof, and lent him the Book (nor with the invention of* Loga-rithms *he uſing* Rathborn's *Chain (with whom he*

had

had been well acquainted, as he told me) and the common or plain kind of Scale therewith, which I said to him, was to make that of no better use for plotting than any other ordinary chain: But now he laid them aside; except for measuring alone without plotting (as he usually did when not required to make a plot) he might perhaps use Rathborn's *chain sometimes for the more niceness or preciseness in measure, as he should think fit. And some years after that, he had the like scale for* Gunter's *chain made more neatly for him in Box by Mr.* Thompson *in* Hosiar-lane, *as himself then, and Mr.* Anthony Thompson *since told me, upon my mentioning this manner of Scale unto him: and which he said, was the only one of this very kind, that he had ever made or seen before or since to his utmost remembrance; so that he did not now well remember the making of it.*

I would have annexed a Draught and very brief description of these Scales for Land-measure only, to my Tactometrie, *as another Appendice, surveying of Land comming then into greater use and esteem than ordinary, both in* England *and* Ireland, *but Mr.* William Leybourn *having then newly set forth a small tract of his own, of surveying, told me, it might problably not be long before he should enlarge that work; and that then, if I pleased, he would insert my Scale therein; which I was very willing unto, as thinking it would do better there,*

to

to be more generally and easily made known to Surveyours, (most of which that were then imployed being but novices or young beginners in the Art) and so sooner brought into use: but I was then out of the way. And so against his 3d. impression, or 2d edition thereof in Folio, *he asking me for it, I delivered a draught thereof straightway unto him: But when this impression came forth, I found therein only the draught of an ordinary diagonal Scale, to an inch (which was the first diagonal Scale, I think, that had been shewed or mentioned in any Book of Survey before) and a brief application thereof to* Gunters *chain. And so mine having been thus twice omitted, I thought not to publish any thing thereof afterward, till that about two years after I being confined to my Chamber constantly a good while, by reason of an hurt I had got in the City; I was put thereupon by a friend who came then to see me, to whom I had some years before hinted the same: & which therefore in that my solitary confinement, I did set my selfe unto, for the recreation and allevation of my mind now and then: and the rather considering with my self that surveying of Land was likely to come shortly after again into the like use as a few years before: this hapning at the time of our Kings restoration to his Right. And so which occasioned me thus to enlarge my conceits thereupon, being indeed more than I intended before. And which I shewing unto the fore-*

foreſaid party, he ſaid he would endeavour the Printing of it, if he could but meet with ſome other convenient mathematical peece going to the Preſs, to joyn it with (it lying in his way ſo to do, more than in mine) thinking it would do moſt handſomely ſo, even as my ſelf alſo did and deſired. But which till this opportunity could not well be effected; and that now by the candid conceſſion and approbation of the moſt ingenious and expert Authour of this preſent book of the Art of Surveying, to which it is annexed.

An

An Additament.

AND here it coming into my mind to consider, whether or no the true content of a plat of Ground, as 'tis laid down from the Pole, Chain, or other Line for Land-measure, upon Paper (as is first most usual) by a Scale and Compasses, might be discovered without the same, (that is, without trapezial or triangular partition or resolution of the Plot, or any manner of measuring thereof) wholly together, as it were, in the lump (if I may so speak) I did soon bethink my self, how that as the solid content of any solid (or liquid) body, of what matter or substance soever, might be discovered or obtained by its weight, from the proportion between the magnitude and gravity, or dimensional and ponderal quantity, first found out in some certain portion or quantity thereof, by a certain measure and weight assigned: (as I formerly shewed in my *Tactometria*; and particularly in Iron and Water, upon special occasions.) So likewise might the area or content of any flat superficies or Plane, being drawn upon any moveable and weighable matter or substance, (as Paper most commonly, and so parchment, paist-board, &c.) be discovered or produced accordingly. For although such a superficial substance or materiate thing comes not under the dimension of depth or thickness [no not the thickest sort thereof; for we

we uſually allow not that dimenſion to the thickeſt board or plank, or tile, brick, or ſtone, for pavement, though theſe have commonly a conſiderable thickneſs, eaſily meaſurable, as from ½ Inch to 3 Inches or more, in Plank, and to 6 Inches or more, in broad paving ſtone, &c. but are meaſured only upon the flat or by the ſquare, as they vulgarly ſpeak, that is, as a plain *ſuperficies* is] yet the thinneſt and lighteſt ſubſtance that is, will ſhew weight. And ſo dare propound this thing, as one of the moſt curious and nice operations or experiments to be performed by the Ballance.

But the main objection againſt it (by ſuch eſpecially as have a good inſight into the nature of Paper, and the other like ſubſtances aforenamed) will be, the unevenneſs or unequalneſs of paper, &c. in general, in the ſubſtance or thickneſs; to wit, that there is hardly a ſheet (or half-ſheet) to be had, ſo cloſely and equally wrought, or compact throughout, as ſhall hold the like weight exactly in every particle thereof, anſwerably or proportionably to the whole. To which I anſwer, that albeit the more ordinary or mean or coarſer ſorts of paper may well be ſuch; yet the finer, richer, and thicker ſort (ſuch as *Dutch* and *Venice*-paper; for I mean not the ſmootheſt always and large, thick plotting paper) which ſeem both to the ſight, and feeling, to be of equal ſubſtance or thickneſs throughout, as near as well may be, are probably for the moſt part otherwiſe in this reſpect; and will not conſiderably alter or differ in gravity or ponderity throughout, eſpecially in one and the ſame ſheet.

Another objection may probably be, that the

ſame

ſame peece of paper will not always weigh alike, but alter and differ therein, according as the ſeaſon or weather is, to make it drier or moiſter, or the place where tis laid. To which I alſo anſwer, that to avoid that ſcruple, it will be beſt to keep it always in as dry a place as one can; be it but for common uſe-ſake, or elſe to dry it moderately, when tis to be weighed: however that matters not, whether it be then drier or moiſter (and ſo lighter or heavier) ſeeing that it will hold a like weight proportionably throughout the whole peece or ſheet. However it be, the thing here propoſed (being ſimply, abſolutely and abſtractly conſidered in it ſelf) is as certain and true as any other in the *Mathematicks*, even from *Mathematical* reaſon it ſelf, beyond or above which, there is none in humane nature, if it be rightly and throughly pondered.

And becauſe the more ingenious practical Reader is ſeldome or never well ſatisfied with bare diſcourſe, rule or precept, in theſe kind of matters, without exemplary illuſtration, or demonſtration thereof; Therefore (and for the curioſity of the performance, more eſpecially in ſuch a ſmall Plot as I have here laid down) I will give for examples ſuch particular experiments as I thought fit to make upon the foregoing Trapezial Figure or Plot, to compare the ſame with the content thereof found by my ſcale-meaſure; and that very faithfully, as they were made with all the accuratnes that might be, as not being my ſelf fully contented in any thing of this nature, without trial or experience of the ſame be it never ſo agreeable to reaſon; or the Theorical grounds of Art.

And the first which I made, was upon a quarter of a sheet of ordinary or mean-priced Paper, yet which seemed to be of as even and equal substance or thickness throughout, as could well be discerned: and out of which I did cut 35 square Inches, with all possible precisenes (supposing a peece of many Inches together to be better for this purpose than one Inch singly.) And had the same weighed with as great precisenes, at *Goldsmiths-hall*, by my good old friend *Mr. Alexander Jackson*, Assay-master there, and that by a small subtile Ballance, which would turn upon the 100th part of a grain. (whose helping hands I had above a dozen years before this, in my former statical or stathmical experiments, delivered in my Atactometrical Appendix: and again of late in the three notable mineral and medicinal waters, in 3 Counties by *London*, namely, *Tunbridge*, *Epsome*, and *Barnet*, which I there omitted) and found this peece to weigh, 26 grains, and 12 mites, (according to the division of the grain there; a mite being $\frac{1}{20}$ grain) which is by decimal division, 26. 6 grains. And which gives the weight of one of these Inches alone, 0. 76 grain. But weighing two Inches thereof together; we found them to be $1\frac{1}{2}$ grain, which give to 1 Inch 0.75 grain (or $\frac{3}{4}$ grain) so that the difference is but $\frac{1}{100}$ grain. And my Trapezial plot cut out of the same peece of 35 Inches precisely by that which I drew first by my scale, weighed, 2 grains and 1 mite, *viz.* $2\frac{1}{20}$ gr. which is decimally 2. 05 gr. Now to discover the content hereof, (and first in Inch-measure) I argue by proportion from weight to superficial or square measure, thus: If 26. 6 grains, give 35 square Inches, or 0. 76 grain gives

gives 1 Inch, what ſhall 2.05 grains give? Anſwer is, 2.697368, &c. Inches: (And which meaſured by my Diagonal Scale of an Inch into 100 parts drawn upon the Land-ſcale, is neereſt, 2,6937) Then ſeeing that the pole-meaſure is deduced from Inch-meaſure, in the plot-ſcale; and that is in our preſent draught ¼ Inch: ſo that a ſquare Inch upon the ſcalar or paper-plot, repreſents 256 ſquare perches on the ground: Therefore I ſay next, If 1 Inch gives 256 p. what will 2.697, &c. Inches give? Anſw. 690.5263 &c. p. which exceeds the true ſcale-meaſure (679.6368 p.) by 11 p. almoſt: or rather working immediately by the ſquare poles in the Inch, 256. gives the ſame, *viz.* If 26.6 grains give 8960 p. or brieflier, if 0.76 grain give 256 p. then 2,05 grains will give 690.526 p.

Or it may be had immediately in *Gunter's* meaſure, by the number of ſquare chains in an Inch ſquare, *viz.* 16 here: for ſo the content will be found, 43.1579 ch. exceeding the true ſcale-conten (42.4773 ch.) by 0.6806 ch. which give 10.8896 p. as before.

The ſecond experiment, I made upon a peece of ordinary paper of 21 ſquare Inches (7 one way, and 3 the other) which weighed by the ſame ballance 20 ½ grains, and ½ mite, *viz.* 20 11/20 grains in the leaſt terms, which is decimally, 20.275 grains exactly: and which give to one of thoſe Inches, 0.965, &c. grain. But one Inch thereof by it ſelf, weighed neareſt 1 gr.—½ mite, *viz.* 1—1/40 gr. which is decimally, 0.975 gr. preciſely, and ſo the difference is 1/100 gr. as in the firſt. And the Trapezia cut out of the ſame leaf of p-

per, weighed 2 ½ gr. and 2 mites, *viz.* 2. 6 gr. which together with the weight of that one Inch ſingly, 0. 975 gr. gives the content immediately in pole-meaſure, (by the aforeſaid proportional argumentation) 682. 6666 p. infinitely, which exceeds the ſcale-content onely about 3 p. But if it were done by the weight of 1 Inch 0. 965, &c. gr. or by the whole weight of the ſaid 11 Inches: Then would the content of the plot be 689. 4. p. exceeding the true content almoſt 10 p. which comes very near the former experiment. So that in this particular experiment, the difference of $\frac{1}{100}$ gr. in weight, makes a difference of 7 p. *fere*, in meaſure.

And after this, I being informed (by the no leſs profound Mathematician, than Phyſician and Philoſopher, Doctor *Charles Scarburgh*, my honoured, worthy Friend) of a new faſhioned Ballance in *Greſham-Colledge London*, in the hands of the very learned Doctor *Jonathan Goddard*, Profeſſor of Phyſick there, that would turn with $\frac{1}{1000}$ gr. I ſoon repaired to him for the making of theſe very experiments over again, to ſee which would come neareſt the truth: But he told me, that his Ballance was out of order, having not been uſed a year before, and that it would at the beſt hardly turn upon $\frac{1}{500}$ gr. but eaſily enough on $\frac{1}{200}$ gr. however he was willing (out of his candour and civility) to try over an experiment for me: and that which I firſt offered to him, was the latter of theſe two already handled; only in the ſame ſingle Inch of paper, which weighed at *Golde-ſmiths-hall* 0. 975 gr. And which (after much adoe to rectifie his ballance as near the matter as poſſibly he could, & which he did very

very nearly) he found to weigh (in several odd parts of a grain, he having not the decimal division thereof) 1--$\frac{9}{800}$ gr. which fraction is decimally .01125, and so the whole weight, 0. 98875 gr. exactly, that is, centesimally 0. 99 *fere*, and *Mr. Jacksons* is 0. 98 *fere*. And then the weight of the same Trapezial paper-plat, he found in these several parts; gr. $2\frac{1}{2}$, $\frac{1}{10}$, $\frac{1}{50}$, $\frac{1}{100}$, $\frac{1}{200}$; all which together, are by decimal conversion, 2. 585 gr. very nearly agreeing with the former, 2. 6 gr. which two by the foresaid proportional argumentation or ratiocination from weight to measure, do give the area of the plot, 669. 2895 p. wanting of the former experiment (682. 66 &c.) about 13 p. and of the true content (679. 6368 p.) about 10 p. which defect very nearly agrees with the two former excesses. And finding this so troublesome to him, I would not trouble him any further herein. And truly himself then aswel as I, judged that kind of ballance to be no better than the other for exactness in weighing: and it seemed to be much more troublesome and tedious in the use.

A third experiment was upon a small peece of fine *French* parchment, cut out to 4 Inches sq. very precisely, which weighed by the foresaid ballance and weights at *Goldsmiths-hall*, 22 gr. and $4\frac{1}{2}$ mites, that is decimally 22. 20625 gr. exactly, which give to 1 Inch thereof 1. 38789 gr. and 1 Inch cut out alone, weighed 1 gr. 6 mites, that is decimally 1. 3 gr. And the same Trapezia cut out of the same peece, weighed $3\frac{1}{2}$ gr. and 3 mites, that is, 3. 65 gr. just. Then arguing by proportion from the whole peece to the plot, in gravity and magnitude, or weight and measure; the content of the

plot will be produced immediately in pole-measure (or first in Inch-measure, and thence in pole-measure, which you please) 673. 2519 p. which wants of our scale-measure, only about 6 p. And these operations may (for the most part) be best expedited by the Logarithms.

And these experiments were all made in a dry season, though at several times much apart: however the plot-materials being carried each time in my pocket, a good way to the places of weighing, must needs keep them in a like temper every time, so as they could not sensibly alter or differ in their respective gravities.

And here mark by the way, how that the difference of weight which may ordinarily happen in 2 sq. Inches, or other like and equal peeces or figures of the same paper, &c. though cut out close together severally, may not always (or oftenest) be from a different or unequal substance thereof (as most will be apt ignorantly to object, though it be not likely) but rather from some difference in cutting them out, although there may be no difference in drawing or delineating them: and therefore every such peece to be thus used, must be cut out in every line or stroke of its perimeter precisely to an hair (as we commonly speak) and that by a direct, or down-right section (which is the surest) as near as may be, with a small, sharp-pointed pen-knife, or the like, to eschew that error: for that the least moment, in a manner, of paper or parchment, more or less, especially in so small a peece as an Inch, or our present plot-figure, being to be weighed by a very small, subtile, nice, nimble ballance (as will not bear ones ordinary breath,

near

near it, or the leaſt motion of the air almoſt, or noiſe; as I have formerly declared elſewhere) will be ſenſibly diſcerned thereby; ſo as to alter the weight of the figure ſomewhat, and conſequently its meaſure to be produced thereby; as is ſeen in our foregoing experimental examples, where $\frac{1}{100}$ gr. weight in the Inch, makes a difference of nigh 7 p. in the meaſure of the plot, by the ſame ballance, in one; and about 13 p. in another trial of the ſame, by two different ballances (though not in this preſent caſe of cutting them out) the difference of weight in the ſame ſingle Inch of paper by them, being 0. 0:4 gr. *fere*, and in the ſame trapezial plot, 0. 015 gr. exactly; either of which is $\frac{1}{100}$ gr. nearly.

And here I may queſtion whether any ordinary Surveiour will be able to meaſure ſo ſmall a plat of ground as this, more near the truth, eſpecially by a common, plain Chain, and Scale; or the Pole divided into but 4 or 8 parts, as is moſt uſual. But ſurely the larger and weightier the peece of paper (or parchment) to be weighed is, the leſſer will be the errour committed, or the truer will be the meaſure produced by this way; as being to be performed by a bigger ballance or weight-ſcales, which will be more eaſily ſet, by ſome greater parts of weight (or of a grain) than the ſmall, tickliſh ones, ſuch as we here uſed, can be: Only to find out the weight of one Inch, or rather more, of the ſame ſort of paper on which the plot is drawn (as is requiſite for working out the content of the plot in a proportional manner, as before is ſhew-

ed, and which in a large plot will do best to be us thereout, which in mine I could not do) will require a smaller ballance.

And indeed this way of finding out the content of a plat, or plain figure, will be of best use in the largest grounds, as Marishes, Fens, Mountains, Woods, and the like; and may probably come as near the truth herein, as the ordinary way by Scale and Compasses, especially that being undertaken by our more ordinary or vulgar Surveyours, who if they can come but within an 100 *acres over or under in* 500, *or* 1000 *at most, (and that chiefly in such grounds) they think it well enough done: and specially such as were (for the most part) employed in our late time of troubles, in the State-surveys, in* England *and* Ireland. *Nay, I may say so by our better Surveyours perhaps, using only the common scales in their plotting. For mine own part, if I were employed in Land-survey, I would in larger and ruder grounds, or spatious Plats, use this very way, for as much certainty as any other, and probably more speediness sometimes, in computing the contents thereof (and of this judgement did the aforenamed Doctour* Goddard *also seem to be, when I mentioned this thing unto him,) And to this end, may a Ballance or Scales be had sufficient to weigh half a pound-weight (or a pound) that will be cast or turned by* $\frac{1}{5}$ *or* $\frac{1}{10}$ *gr. as is at* Gold-smiths-ball, *which I have made use of in some other considerable experiments, that I have not fou d*

to

to be done by any other body. For the biggeſt Standard-ballance commonly uſed there, that will well bear 40 *l. weight, will ſenſibly turn with* 1 *gr. as I have often had occaſion to try, and have formerly mentioned it in my weighing of ſeveral waters together thereby, ſeveral times.*

And by this way may be diſcovered the Area *of any irregular plain ſuperficies, that is not rectilineal, and ſo not plainly angular, but curvilineal, and which cannot be obtained any other way; like as I ſhewed in my* A-tactometria, *for diſcovering the ſolid capacity of any irregular body by weight,* &c.

But now if the Surveiour ſhall make a ſcruple of being fitted or furniſhed with convenient parts of a Grain-weight for this purpoſe: I tell him, that if he can meet with a paper, or parchment, (or other like material) one Inch ſq. whereof will weigh a juſt grain, by a ſmall ballance, or very near it: [as my ſelf did in making theſe experiments, in two ſorts of Paper, the one whereof was that of the ſecond experiment, where 1 *Inch ſingly, weighed* 0. 98 *gr.* fere, *by one ballance, and* 0. 99 fere, *by another; which falling ſo nearly upon* 1 *gr. it might well enough paſs for a gr. as to its diviſion into many parts, without any ſenſible errour, both as Doctour* Goddard *and Maſter* Jackſon, (*two familiarly acquainted*) *acknowledged with me. And the other was* 2 *ſeverdl Inches of a finer and thicker paper, each of which weighed juſt* 1 *gr. by* 4 *different ballances, the leaſt whereof was*

that

that before uſed; and by which, 96 ſq. Inches cut out of the ſame ſheet, weighed 4 *p.w.* 2 *gr.* $\frac{1}{2}$ *mite, or* $\frac{1}{40}$ *gr. that is decimally,* 98.025 *gr. juſt: which give the weight of one of thoſe Inches proportionably,* 1. 02109, &c. *gr. And the ſame* 96 *Inches by a little bigger ballance, at the ſame time and place, weighed* 4 *p.w.* 2 *gr.* viz. 98 *gr. entirely; which give to* 1 *Inch,* 1. 0208, &c. *gr. which two Inch-weights do ſcarcely differ between themſelves, and ſo not conſiderably from the weight of each of the two ſingle Inches, being but* .02, *or* $\frac{1}{50}$ *gr. in way of exceſs: thoſe two Inches being cut out of one leaf or half-ſheet, and the* 96 *out of the other (* viz. 12 *one way, and* 8 *the other) which ſhews the near equality or eveneſs of that whole ſheet throughout.*] *Then he may eaſily divide it into* 100 *diſtinct parts, which is ſufficient for reſolving almoſt any nicety depending upon weight: but he need not divide it into* 100 *parts diſtinctly, but only ſuch as will ſerve the turn, ſo as to afford any number of Cents: which I found by trial to be the beſt in theſe vulgar parts or fragments, (together with* 2 *decimals:)* viz. $\frac{2}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{8}$, $(\frac{1}{10})$ $\frac{1}{20}$, $\frac{1}{25}$, $\frac{1}{50}$, $(\frac{1}{100})$ *all which are exactly expreſſible in centeſms (except* $\frac{1}{3}$, *which runs into milleſms) to wit,* .5 (*or.* 50). 25. .20 (.125). 10. 05 .04 .02 .01: *and by which therefore may be counted any number of Cents in a grain, to* 100, *in a continued order, having only one ſingle cent. But for want of ſuch an Inch, be may*

cut

cut out a convenient peece of any paper or parchment, in a rectangle form, and diminish it by degrees on one side parallely, till it come to a grain-weight, and then divide it as before is directed. Or else (for need) he may make a square Inch (or more) of any paper, &c. serve his turn sufficiently, calling it a Grain, and dividing it accordingly: seeing it matters not to have the common set parts of any certain, customary Weight (or any such weight it self entirely) only for obtaining the proportion of gravity or ponderity desired, between several things; no more than it doth to have the two weight-scales of equal weight (or to force them thereto; by helping the lighter with something to poise it equally with the other: for then it comes all to one pass) so as the several things to be weighed, be put in the same Scale, and the same kind of weights in the other. Or no more than it doth to have the usual parts of any set, statute-measure (or any such Measure it self) only for finding the proportion of magnitude or dimension between divers things, required; so as those things be measured by the very same Measure, and parts thereof, whatever they be, at the will of the Measurer. And more I could say to this very purpose, but for being too tedious, which some perhaps may think I have been already; although here be nothing but what I think to be requisite: being unwilling to omit any circumstance, convenient or conducing to our present matters.

I will conclude this whole Appendix with the beginning of the renowned Mathematician (but a Divine by profession) *B. Pitiscus* his Preface to his *Geodetics*; in commendation and estimation of the Art here handled, *viz. Socrates hunc principalem Geometriæ finem esse statuebat, ut agrum planum metiri dividereque possis. Tanti Philosophi judicium secuti, istius generis problematibus merito primum locum attribuimus. Socrates* held the principal end and aim of Geometry to be the measuring and dividing of a plain peece of Ground. And we (saith he next thereupon) having followed the judgement of so great a Philosopher, do deservedly give the first place to problems of that kind. That is, he puts them before his other kinds of Mathematical problems, next after his *Trigonometrie*; which are all for illustration thereof, &c.

J. W.

The end of the Appendix to the sixth Book.

The ART SURVEYING

The Seventh Book.

Wherein is ſhewed both Arithmetically and by Tables, how to meaſure exactly all kind of plain Superficies, as Walls, Timber-work, Roofs of Houſes, Tyling, Boord, Glaſs, Wainſcot, Pavement, and the like; as alſo Timber and Stone, With a detection of ſome common errours uſed by many in the performance thereof.

CHAP. I.

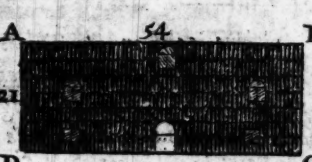
To meaſure all manner of Buildings, as Walls, Tyling, Timber-Roofs, Floors, &c.

FOraſmuch as the difference between the meaſuring of Land, and theſe is only this that land is meaſured by the Pole or Perch, but theſe, Some of them by one kind of meaſure, and ſome by another, as Walls and

and Tyling by the Rod of 18 feet ſquare, Timber-work by the ſquare of 10 feet, Pavement and Wainſcot by the yard, or foot, and laſtly, Boord and Glaſs by the foot only.

Therefore in meaſuriug any of theſe things conſideration muſt firſt be had to the juſt form and figure thereof, and then according to the Rules delivered in the third Book, you may ſoon find the area, or ſuperficial content. And foraſmuch as it is very requiſite and neceſſary for a Surveyor to know how to meaſure all manner of Buildings, as Walls, Timber work, Tyling, Floors, and ſuch like, I ſhall in the following Examples make illuſtration thereof.

Suppoſe there be a wall in the form of the figure A B G D, that is 54. feet in length and 21. feet in height, and it is required to know how many rods yards, and feet are contained therein. Firſt I multiply 54 by 21. and the product is 1134 feet, which I divide by 324. (becauſe there are ſo many feet in one Rod) and the Quotient is 3. Rods, and 162. feet remaining, which I divide by 9. (for ſo many feet are contained in a yard) and the Quotus is 18. and nothing remaining, ſo that when the wall is 54. feet long, and 21. feet high, there are contained therein 3. rods, 18. yards, and 0. foot, which is exactly 3. Rods and a half; for 36. yards, or 324. feet, make a Rod, 18. yards, or 162. feet, half a Rod, and 9. yards, or 81. feet, a quarter of a Rod,



But

But in measuring Govells, Dormant-Pikes, and the like, which are Triangular, you are to measure them as tri-angles, as is taught in the third Book; as for example. Suppose *A B C* be a Govel, or Dormant-pike, whose Base B C is 18. feet, the height, or Perpendicular 15. feet. Here (according to the 7 Problem of the 3 Book) I multiply the Perpendicular 15. by the Semibase 9. and the Product 135. is the content in feet, which reduced into yards, by dividing it by 9. makes exactly 15. yards, for the true content of the Dormant-Pike.

But in measuring of Chimneys, which require more accuratness of Workmanship then other ordinary Walls, they are usually accounted at double measure. But first to measure them as single measure, take the length of the Brest-wall, and the two sides or angles, which multiply in the height, as before, and the product of that multiplication being doubled, yieldeth the content, according to double measure, which is customarily allowed, yet some workmen are so covetous and unconscionable, that they are not content to have double measure for the Brest-wall, and the two angles, but would have the Back of the Chimney double measure also, whereas (for the most part) the Chimney is made against a govel, which is measured *per se*, and so they would have that three times measured, which is and ought to be accounted but as single measure.

Sup-

Suppose this figure A B C D E F G H K be a Chimney to be measured, and the content is required according to double measure.

First, I begin at the Base, and take the length of the Brest-wall o z, and the 2. angles K x and o H which together are 23 feet, then I take the height of the Square H F 17. f. 25. which multiplied together produce 369 f. 75, for the content of the Figure F G H K.

2. For the Square D ∗ E ∗, the length of the Brest-wall and the 2 angles D P E is 14. feet, the height D ∗ 5. f. 25. which multiplied together make 73 f. 50, for the content of the Figure D ∗ E ∗.

3. I take the length of the next Square B C h p. 9. p. 25 and the height B b 8 f. 25. which multiplied together. produce 76 f 31.

4. The compass of the Chimney-shaft A is 8. feet, the height 6. which multiplied together, make 48. feet.

Lastly adding these 4. sums together, and doubling the Aggregate, it produceth the content of the whole Chimney, according to double, or customary measure, as you see in this Paradigme.

		Feet.	p.
The Squares	F H G K	369.	75
	D ∗ E ∗	73.	50
	B C h p.	76.	31
The Shaft	A	48.	00.
	Aggregate	567.	56

The

The Content of the Chimney according to customarie measure, } 1135:12
which reduced into Rods, as is shewed before, maketh 3 roods, 18 yards 1 foot and $\frac{12}{100}$.

This is all the measure that can be allowed when the Chimney stands in a Govell or Side-wall, in which case, the Back of the Chimney (here not measured) is accounted as part of the Govell; but if it stand by it self (which seldome hapneth) then the back is to be measured with the rest of the Chimney. But because I am the first (to my knowledge) that ever wrote of matters of this nature, I will forbear to speak further hereof at this time.

But because all men have not skill to perform this Arithmetically, they make use of *Tables* set upon Rules, shewing how many feet and inches in length will make a Rood, according to any height, which way, though it be not so usefull and compleat as the former, yet in regard it is much practised and common, I shall for variety, and chiefly for their sakes that cannot readily multiply and divide, present you with this new Table of Rood-measure, as I have faithfully calculated the same which may be set upon a Ruler.

A Table of Rood measure, shewing how many Feet and Parts of a Foot in length, will make a Rood for any height from 1 Foot to 60 Feet.

Heigh	F.	Parts	Heigh	F.	Parts	Heigh	F.	Parts
F 1	324	000	F 21	15	428	F 41	7	902
2	160	000	22	14	727	42	7	714
3	108	000	23	14	087	43	7	535
4	81	000	24	13	500	44	7	364
5	61	800	25	12	960	45	7	200
6	54	000	26	12	461	46	7	043
7	46	286	27	12	000	47	6	893
8	40	500	28	11	571	48	6	750
9	36	000	29	11	172	49	6	612
10	32	400	30	10	800	50	6	480
11	29	500	31	10	451	51	6	35
12	27	000	32	10	125	52	6	231
13	24	923	33	9	818	53	6	113
14	23	143	34	9	529	54	6	000
15	21	600	35	9	257	55	5	891
16	20	250	36	9	000	56	5	786
17	19	059	37	8	757	57	5	684
18	18	000	38	8	526	58	5	586
19	17	052	39	8	308	59	5	491
20	16	200	40	8	100	60	5	400

Explanation:

Enter the Table, finding the height of the Wall, either in the 1. 3. or 5, Columns, and in the next towards the right hand, you have the feet and parts of a foot, that you are to go in length for a Rood.

Example. When a Wall is 16 feet in height, you are to measure in length for a Rood, 20 feet, and 250 parts, which is a quarter of a foot, or 3 inches, as you may see by this Table.

83	167	250	333	417	580	583	667	750	833	917	1000
1	2	3	4	5	6	7	8	9	10	11	12

Seek the parts given in this Table, & you have the inches answering thereto; and if you make proportion, you may take the parts of an inch.

After the same order, Tyling and Sleat-work are measured by the Rood of 18 feet square: and although Timber-work, as Roofs of Houses, Partitions, Floores, and the like, are reckoned by the Square of 10 feet, yet in regard they are all measured by one and the same rule, which I have fully explained already in this Chapter, I will not adde any more Examples of that kind.

CHAP. II

To measure Boords, Glass, Pavement, Wainscot and the like.

THe same course that we used in the mensuration of Buildings, is also to be held in the dimension of Boords, Glass, Pavement, and

Wainſcot; only as we ſaid above, they are commonly accounted by the foot or yard. But to explain this, I ſhall inſtance only in Boords, which are uſually cut out into long Squares; and to meaſure them, take the length & breadth of the board in inches, and multiply the one by the other; the product will ſhew the content in inches, then to know how many feet are contained therein, divide the ſame by 144 (the number of inches in one foot) and the Quotient will tell you the number of feet, and the remainer is ſo many inches over and above.

Example. Suppoſe you have a Board that is 6 feet or 72 inches long, and 10 inches broad. Multiply 72 by 10, and it maketh 720, which divide by 144 (the number of inches in a foot of flat meaſure) the Quotient is 5, and nothing remaining; ſo that the Board contains exactly 5 feet.

But if it fall out that your Board is broader at the one end then at the other, adde together the breadth at each end, and then take the one half thereof for the true breadth, with which worke as before.

But becauſe our common Artificers do for the moſt part, make uſe of Tables and Lines ſet upon Rules, to ſhew how many inches in length, anſwerable to any breadth given, will make a foot, and ſo try by how many times the ſaid quantity is contained in the Board, and account it to be ſo many feet, therefore I ſhall here inſert a Table of Board-meaſure, whoſe uſe followes after the Table.

A Table of Board Measure.

Br		F Pa	Br		F Pa	Br		F Pa	Br		F Pa
1	0	0,083	9	1	0,770	17	2	1,458	25	3	2,145
1	1	0,107	9	2	0,791	17	3	1,479	25	0	2,167
1	2	0,125	9	3	0,812	18	0	1,500	26	1	2,187
1	3	0,145	10	0	0,833	18	1	1,521	26	2	2,208
2	0	0,166	10	1	0,854	18	2	1,542	26	3	2,229
2	1	0,187	10	2	0,875	18	3	1,562	27	0	2,250
2	2	0,208	10	3	0,897	19	0	1,583	27	1	2,270
2	3	0,229	11	0	0,917	19	1	1,604	27	2	2,291
3	0	0,250	11	1	0,937	19	2	1,625	27	3	2,312
3	1	0,270	11	2	0,958	19	3	1,646	28	0	2,333
3	2	0,291	11	3	0,979	20	0	1,667	28	1	2,354
3	3	0,312	12	0	1,000	20	1	1,687	28	2	2,375
4	0	0,333	12	1	1,027	20	2	1,708	28	3	2,395
4	1	0,354	12	2	1,044	20	3	1,729	29	0	2,417
4	2	0,375	12	3	1,062	21	0	1,750	29	1	2,437
4	3	0,396	13	0	1,083	21	1	1,770	29	2	2,458
5	0	0,417	13	1	1,104	21	2	1,791	29	3	2,479
5	1	0,437	13	2	1,125	21	3	1,812	30	0	2,500
5	2	0,458	13	3	1,146	22	0	1,833	30	1	2,521
5	3	0,479	14	0	1,167	22	1	1,854	30	2	2,542
6	0	0,500	14	1	1,187	22	2	1,875	30	3	2,562
6	1	0,521	14	2	1,208	22	3	1,896	31	0	2,583
6	2	0,542	14	3	1,229	23	0	1,917	31	1	2,604
6	3	0,562	15	0	1,250	23	1	1,937	31	2	2,625
7	0	0,583	15	1	1,270	23	2	1,958	31	3	2,646
7	1	0,604	15	2	1,291	23	3	1,979	32	0	2,667
7	2	0,625	15	3	1,312	24	0	2,000	32	1	2,687
7	3	0,646	16	0	1,333	24	1	2,021	32	2	2,708
8	0	0,667	16	1	1,354	24	2	2,041	32	3	2,729
8	1	0,687	16	2	1,375	24	3	2,062	33	0	2,750
8	2	0,707	16	3	1,395	25	0	2,083	33	1	2,770
8	3	0,729	17	0	1,417	25	1	2,104	33	2	2,791
9	0	0,750	17	1	1,437	25	2	2,125	33	3	2,812

The use of this Table.

Find the breadth of the Board in the Table, and the number there found, multiply by the feet contained in the length of the Board, and from the product, cutting off the 3 last figures towards the right hand, you shall have the number of feet the Board contains: and the figures cut off will shew the parts of a foot, of which parts 250 is a quarter of a foot, 500 half a foot, and 750 three parts, &c.

Thus in the former Example, the Board being 10 inches broad, and 6 feet long.

In the Table 10 inches broad gives	0, 833
Which multiplied by	6
The Product is	4, 998

That is 5 feet as before.

I need not enlarge my discourse upon this subject, for he that knows how to measure any Figure according to the Doctrine of the third Book, and what we have written of Board-measure in this Chapter, will be throughly enabled to measure, not only Boards and Glasse, but also all manner of Pavement, Floores, Wainscot, and such like, which all depend upon one and the same Geometricall ground, though they be reckoned by different measures, as by the Rod, Square, Yard or Foot, according to the Custome of the place, and therefore we shall conclude this Chapter.

CHAP.

CHAP. III.

Of Solidmetria, *Or the Menſuration of Solid Bodies, as Timber and Stone: and firſt of that which is ſquared.*

A Solid Body is that which hath both length, breadth and thickneſſe, as Timber, Stone, and ſuch like, which are commonly meaſured by the foot. And herein you are to obſerve, that a foot of Timber or Stone is accounted a foot ſquare every way, in the form of a Die, whereby it appears, that a foot of Timber is 12 times more then a foot of Board; ſo that a foot of Board being 144 inches, a foot of Timber muſt be 1728 inches.

For Timber-ſticks that are ſquared, you may find the content thereof on this wiſe. Multiply the breadth by the thickneſs, and then multiply the Product by the inches of the length, ſo will you have the Solid content of the whole piece of Timber in inches, which being divided by the ſolid inches in one foot, namely 1728, the Quotient will ſhew how many feet are in the piece of Timber.

Example. Suppoſe a piece of Timber be 9 inches thick, 15 inches broad, and 12 feet, or 144 inches long. Firſt I multiply 15 by 9, and the factus 135 is the area of the Plain, which I again multiply by the length 144, and the Product 19440 is the content in ſolid inches, which being divided by 1728 (the ſquare inches in one foot) the Quotient will be 11.25, ſo that when the piece of Timber is 9 inches in thickneſs, 15 inches in breadth, and 12 feet in length

length, there is contained in it 11 feet, and a quarter of a foot, according to the true and substantiall grounds of Art.

But yet I know it is a very common thing amongst Carpenters, to adde the broader and narrower sides together, and to take the half thereof for the true Square, which way (though it be much used) is very erroneous, especially when the difference between the sides is much; as in the former Example, where the one side is 15, the other 9, and the sum 24; therefore they reckon 12 for the true square, and so conclude there are 12 square feet of Timber in that piece, whereas there are exactly but 11 feet and a quarter, as is proved above.

To find the true square of a piece of Timber when the one side is broader then the other. Multiply the sides together, and the square Root of that Product yieldeth your desire.

As in the former Example, I multiply the one side 15 inches, by the other 9, and the Product (as before) is 135, whose square Root is near upon 11. 62, which is the true square thereof.

A

A Table of Solidmetria *or Timber-measure, shewing the true quantity of* 1 *foot in length, from* 1 *inch square to* 36.

Sq	F Pa	Sq	F Pa	Sq	F Pa	Sq	F Pa
1 0	0,007	10 0	0,694	19 0	2,507	28 0	5,445
1 1	0,011	10 1	0,729	19 1	2,573	28 1	5,542
1 2	0,016	10 2	0,765	19 2	2,641	28 2	5,640
1 3	0,022	10 3	0,802	19 3	2,701	28 3	5,740
2 0	0,028	11 0	0,840	20 0	2,778	29 0	5,840
2 1	0,035	11 1	0,879	20 1	2'849	29 1	5,941
2 2	0,043	11 2	0,919	20 2	2,918	29 2	6,043
2 3	0,052	11 3	0,959	20 3	2,990	29 3	6,146
3 0	0,062	12 0	1,000	21 0	3,062	30 0	6,250
3 1	0,073	12 1	1,042	21 1	3,136	30 1	6,354
3 2	0,085	12 2	1,085	21 2	3,210	30 2	6,460
3 3	0,097	12 3	1,128	21 3	3,285	30 3	6,566
4 0	0,111	13 0	1,174	22 0	3,361	31 0	6,673
4 1	0,125	13 1	1,219	22 1	3,438	31 1	6,778
4 2	0,140	13 2	1,268	22 2	3,516	31 2	6,890
4 3	0,156	13 3	1,313	22 3	3,594	31 3	7,001
5 0	0,174	14 0	1,351	23 0	3,673	32 0	7,111
5 1	0,192	14 1	1,411	23 1	3,754	32 1	7,222
5 2	0,210	14 2	1,460	23 2	3,835	32 2	7,335
5 3	0,229	14 3	1,519	23 3	3,917	32 3	7,448
6 0	0,250	15 0	1,562	24 0	4,000	33 0	7,562
6 1	0,271	15 1	1,615	24 1	4,084	33 1	7,677
6 2	0,293	15 2	1,669	24 2	4,168	33 2	7,789
6 3	0,316	15 3	1,703	24 3	4,254	33 3	7,901
7 0	0,340	16 0	1,778	25 0	4,340	34 0	8,027
7 1	0,365	16 1	1,834	25 1	4,427	34 1	8,146
7 2	0,391	16 2	1,891	25 2	4,516	34 2	8,265
7 3	0,417	16 3	1,947	25 3	4,604	34 3	8,385
8 0	0,444	17 0	2,007	26 0	4,694	35 0	8,507
8 1	0,472	17 1	2,067	26 1	4,782	35 1	8,528
8 2	0,502	17 2	2,127	26 2	4,877	35 2	8,750
8 3	0,532	17 3	2,185	26 3	4,969	35 3	8,875
9 0	0,562	18 0	2,250	27 0	5,063	36 0	6 000
9 1	0,594	18 1	2,313	27 1	5,156		
9 2	0,627	18 2	2,377	27 2	5,251		
9 3	0,654	18 3	2,441	27 3	5,347		

The use of this Table.

Seek the true square of your Timber-stick in inches, and multiply the number found against the same by the length of the Stick in feet, so will the Product shew the content.

Example. Suppose a piece of Timber be 11 inches square, and 12 feet long.

The number answering to 11 inches sq. is,	0.840
Which multiplied by the length	12
	1680
	840
Produceth the content of the Timber-stick	10,080

Again, in our former Example, the true Square was found 11.62, the length 12 feet. But because the Table proceeds by inches, half inches, and quarters; therefore I take the square answering to 11 inches 50 centesms, which is 0.919, and the square of 12 inches is 1000, their difference 81, then, If the difference of half an inch, or 50 Centesms give 81, what shall 12 give? the answer is 19, which added to 919, the true number answering to the square given 11.62 will be 0,938

Which multiplied by the length	12
	1876
	0938
The content of the Timber-stick, as before	11,256

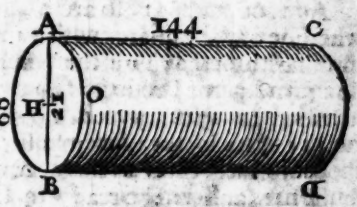
CHAP.

CHAP. IV.

To measure round Timber.

TO measure round Timber, you must first find the area of the Circle (whose circumference is equal to the compass of the Tree) as you are taught in the third Book, and 14 Probleme. And this I shall make clear in an Example or two.

1 Suppose there be a round piece of *Timber*, whose compass is 5 feet and a half, or 66 inches, the Diameter or greatest thickness thereof 21 inches, and the length 12 feet, or 144 inches. First I multiply the Semidiameter A H 10. 50 in half the circumference A O B 33, and the Product is 346.50, which again multiply by the length 144 inches, and the result 4989500 being divided by 1728, the Quotient is 28. 875; so that there is 28 feet of *Timber*, and above 3 quarters of a foot in the stick, whose circumference is 5 feet and a half, and the length 12 feet.



But the work may be abbreviated by the following Table, as I shall shew in the use thereof:

But by the way, I shall here divulge one common errour in measuring round *Timber*, crept in for want

want of Art, which having got poſſeſſion of the greater ſort of Artificers, is (by long continuance) grown almoſt irrecoverable, and that is in girdling of the round piece of timber, or tree, and of that circumference to take a fourth part for the ſquare.

As in the former piece of round timber, the circumference is 66, the $\frac{1}{4}$ whereof 16. 50 they account the ſquare, which multiplied in it ſelf, produceth 272. 25, for the area of the Baſis, which if you multiply by the length 144, the product is 39204.00 the content in inches, which divided by 1728, the Quotient is $22\frac{2}{3}$ feet, which is apparently erroneous, differing from the truth no leſs then 6 whole feet, and that too little, as appears above; which for further triall, we ſhall alſo examine by Mr. *Gunters* Rule, in his ſecond Book of the *Croſſe-ſtaff*, *pag.* 44 *Prop.* 10.

As 1000, to 2821, ſo are 66 inches to 18. 6186 the ſide of the Square, which multiplied in it ſelf, produceth 346. 65, now this being multiplied by the length 144, the Product is 49917. 60, which being divided by 1728, giveth 28 *f.* 88, agreeing nearly with our former way of menſuration.

But in ſuch caſes as theſe men commonly plead cuſtome, and will be ready to ſay, they make allowance for the bark and waſte in hewing; which indeed ought to be done in the price, and not in falſe meaſuring; but leaving this to their own fancies, I ſhall inſert this Table.

A

A Table shewing (by the Compass of round Timber) what is contained in a foot length thereof.

Cō	F.pa	Cō	F.pa	Cō	F.pa
10	0,055	40	0,884	70	2,707
11	0,066	41	0,929	71	2,785
12	0,077	42	0,974	72	2,864
13	0,093	43	1,021	73	2,945
14	0,108	44	1,070	74	3,026
15	0,124	45	1,119	75	3,108
16	0,141	46	1,169	76	3,191
17	0,159	47	1,220	77	3,276
18	0,179	48	1,273	78	3,362
19	0,200	49	1,327	79	3,449
20	0,221	50	1,381	80	3,537
21	0,243	51	1,437	81	3,625
22	0,267	52	1,496	82	3,715
23	0,292	53	1,552	83	3,807
24	0,318	54	1,612	84	3,896
25	0,343	55	1,671	85	3,990
26	0,374	56	1,732	86	4,084
27	0,403	57	1,795	87	4,183
28	0,433	58	1,860	88	4,279
29	0,465	59	1923	89	4,377
30	0,497	60	1,988	90	4,475
31	0,531	61	2,056	91	4,576
32	0,566	62	2,124	92	4,677
33	0,602	63	2,193	93	4,780
34	0,639	64	2,264	94	4,882
35	0,677	65	2,335	95	4,987
36	0,716	66	2,406	96	5,093
37	0,756	67	2,480	97	5,200
38	0,798	68	2,555	98	5,307
39	0,840	69	2,631	99	5,416

The use of this Table.

Enter the Table with the compass of the timber-stick in inches, and in the Columne immediately annexed, you have the true quantity of timber in one foot length, which multiply by the number of feet that the stick contains in length, and the Product will be the true content thereof.

In our former Example, the compass of the stick was 66 inches, so that the quantity of one foot length thereof is found by the Table, to be 2.406, which multiplied by 12, the length of the stick produceth 28*f.* 872, as is evident by the operation.

The number answering to 66 inches is	2.406
Which multiplied by 12 feet the length	12
	4812
	2406
Produceth 28 feet $\frac{872}{1000}$ as before	28|872

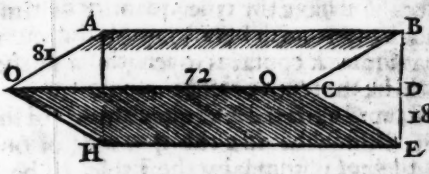
CHAP. V.

To measure Timber having 3, 5, 6, 7 *or more sides equally squared.*

IF Timber be neither round nor four square, but is either Triangular, or else consisteth of more sides then four, you must still find the area of the plain, according as hath been taught in the third Book, and then work as in the former Chapters, for

for the content. But to explain it more fully, I shal adde some Examples.

Example 1. Suppose a piece of Timber consist of three equall sides, each side being 18 inches, the length 6 feet, or 72 inches, as in this Figure. First



I seek the area of the plain BCE=AOH (according to the 7th Probleme of the third Book, and find it 140. 30, which I multiply by the length 72 inches, and the product is 10101/60, which divided by 1728, the quotient is 5. *f.* 846, for the Content of the three sided piece of Timber.

Likewise if all the 3 sides be not equall, yet you may find the area of the plain, according to the directions in the third Book, and then work as before.

But if a piece of Timber consist of more sides then

four, you must still find the area of the Plain.

Example 2. Suppose a piece of Timber have six equall

equall sides, like to this present Figure, each side containing 10 inches, the length 7 feet, or 84 inches; First (according to the 18th Probleme of the 3 Book) I take the Area of the plain *abcdef* 259 80, which I multiply by the length of the stick A f 84, & the Product is 21823|20, which divided by 1726, the Quotient is 12 feet$\frac{3}{4}$, or decimally 12,63

But you may more readily performe any operation of this kind by the Table of Logarithms, as we shall instance in the last Example

As the solid inches in one foot	1728	3,23754
Is to the Area of the plain	259|80	2,41464
So the length of the stick	84	1,92428
		4,33892
To the content of the timber, 12 *f.* 629	As before	1,10138

The like you are to observe in all pieces of Timber, of six, seven and eight sides or more. And thus much briefly concerning round and squared timber.

CHAP. VI.

The Dimensions of Piramids or Cones.

IF a piece of Timber be right lined, having but one base and end in a sharp point, it is called a Piramide; but if the Base thereof be round, it is a Cone, according to the common definition.

The solid content of either of these Figures is found by multiplying the superficiall content, or area, of the Base, by a third part of the length.

Suppose

Suppoſe the Piramide repreſented by the Figure A B C D be to be meaſured, whoſe ſide at the Baſe B C or B E is 18 inches, and the length A B 45 feet, or 540 inches. Firſt I multiply the ſide of the Piramide at the Baſe 18 in it ſelf, and the product 324 is the area of the Baſe, which I again multiply by a third part of the length 180 inches, and the product will be 58320 the ſolid inches in the whole piece, which being divided by 1728, the Quotient is 33 feet, and 1296 parts of a foot, which is 33 feet and 3 quarters.

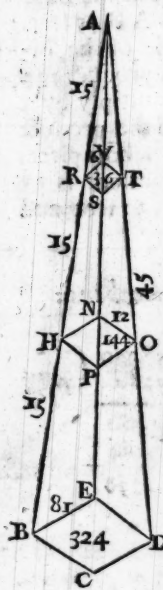
The Operation in common Numbers.

18 ſide of the Piramide
18
144
18
324 Area of the Baſe
180 Third part of the length
000
2592
324
58320 product

58320 *f.*
5184 (33 $\frac{1296}{1728}$
(1728)
6480
5164
1296

The little Piramide following A R S T V is but 6 inches ſquare at Baſe, whole area is 36, which multiplied by a third part of the length 60 inches, produceth 2160, that is 1 foot, and 432 parts, or one foot and a quarter.

The Operation by Logarithms.



⅓ part of the length AR 60		1,77815
Area of the Base 36		1,55630
Aggregate		3,33445
Solid inches in a foot 1728		3,23754
Solid content 1, 250 foot		0,09691

But suppose the content of the Segment ONHBCD were required. The squares at the two ends are 144 and 324, which multiplied together, produceth 46656, whose square Root is 216, for the Geometricall mean square. Now the sum of these 3 squares (*viz.* 144 216, and 324) is 684, which multiplied by a third part of the length 60 inch. the product is 41040, which divided by 1728, the Quotient is 23 feet, and 1296 parts, which is the content of that segment.

Or thus by the Table of Logarithms

Greater square	324	2,51054
Lesser square	144	2,15836
		4,66890 Aggr
Radix	216	2,33445½ Ag.
Sum	684	2,83505
⅓ part of the length	60	1,77815
		Ag

	Aggreg.	4,61320
1728		3,23754
Content 23. 750, as before		1,37566

Again, ſuppoſe the content of the other Segment TVRONH be required, then the work will be thus.

Greater ſquare	144	2,15836
Leſſer ſquare	36	1,55630
		3,71466
Radix	72	1,85733
Sum	252	2,40140
⅓ part of the length	60	1,77815
	Agreg.	4,17955
Solid inches in a foot	1728	3,23754
Solid content	8750	0,94201

That is 8 feet and 3 quarters.

Now if to the ſum of the 2 Segments, you adde the little Piramide ARTV, the Aggregate will be the ſolid content of the whole Piramide.

Thus the greater Segment was before found 23. 750, the leſſer 8. 750, their ſum 32.500, to which if you adde the little Piramide 1. 250, the Aggregate 83. 250, is the content of the whole Piramide, that is, 33 feet and 3 quarters.

After the ſame manner are Cones to be meaſured; as for Example. In the Figure OXYS, the Diameter of the Baſe is 21, the Peripherie 66, the Superficiall content 346. 50, and the length of the Cone 45 feet, or 540 inches; now if you multiply the Area of the Circle 346.50, by the third part of

the length 180 inches, the Product is 62370, which divided by 1728, the Quotient is 36 feet $\frac{162}{1728}$.

By the Logarithms the operation may be more easily performed.

Area 346.50	2,53970
½ part of the length 180	2,25527
Aggr.	4,79497
1728	3,23754
Content of the Cone 36.094	1,55743

The Segments of Cones are measured as the Segments of Piramids, and therefore Examples are needless.

CHAP. VII.

To find both the Superficiall and Solid content of a Sphere, or Globe.

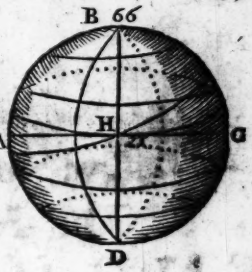
1. *For the Superficiall content.*

MUltiply the Spheres diameter by the Circumference of the same, and the Product will be the thing required.

Admit A B C D H be a Sphere or Globe, whose superficiall content is required. I multiply the circumference 66, by the Diameter or thickness 21, and the Product 1386 is the content of the Convex Superficies

Superficies of that Globe, whether Timber or Stone.

Or multiply the Area of the Circle by 4, and it will produce the Content. Thus the Diameter being 21, and the Periphery 66, the Content of that Circle is 346.50, which multiplied by 4, yieldeth 1386 as before.



2. *For the Solid Content.*

But to find the Solid content of the same Globe (or any other) multiply the Cube of the Diameter by 11, and divide the Product by 21, the Quotient is the solid content.

As in the former Example, the Diameter is 21, whose Cube is 9261, which multiplied by 11, the product is 101871, and this divided by 21, the quotus is 4851, the solid content of the Globe in inches. And thus much briefly for Timber-measure.

The End of the Seventh Book.

The ART of SURVEYING

The Eighth Book.

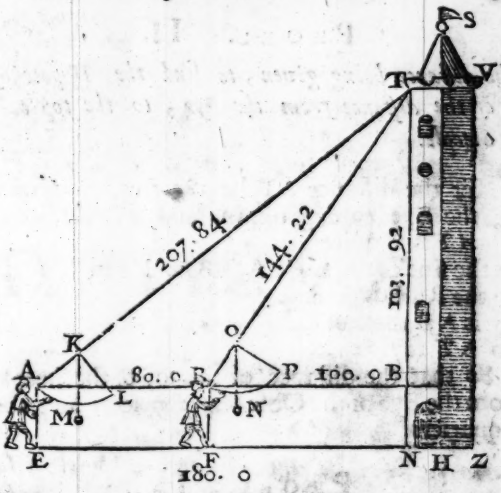
In this Book are delivered certain Problems of Altimetria, *or of the Dimension of the height of such things, as are under our sight, which I confesse may be performed by severall kinds of Instruments, but to avoid Prolixity, we shall at this time shew how it may be effected by the Quadrant only, as being the most known and common Instrument generally now used.*

PROBL. I.

The distance being given, to find the Altitude.

Suppose T V R N to be a Tower or Steeple, whose distance E N or A B is 180 feet, and it is required to know the Altitude of the said Steeple B T, above the eye of the Observator.

Having



Having by the Quadrant observed the angles A K M and M K L, whereof the first is equall to the angle A T B, and the other to the angle T A B, because, that as the angle T A B, is the Complement of the angle A T B. so the angle *M* K L is the complement of the angle A K M.

Suppose then the angle M K L, equall to the angle T A B be 30 deg. o min. and the distance A B be 180 feet, to find the height B T, I say (by the 1 Book, 1 Section, 1 Probleme.)

As the Radius 90 degrees	10,00000
To the tangent of the angle T A B, 30 d. o m.	9,76144
So A B 180 feet	2,25527
To the height required *B T* 103,92 *feet*	2,01671

PROBL.

PROBL. II.

The distance being given, to find the Hypotenuse, or the distance from the Eye, to the top of the Steeple.

LEt the distance A B be 180 feet, the angle at the Eye 30 deg. 0 min. and the Hypotenuse *A T* is required.

As the sine of the angle A *T* B 60 d. 0 m.	9,93753
To the Radius 90 deg.	10,00000
So is A B 180 feet	2,25527
To A *T* 207, 84	2,31774

So that the distance of the top of the Steeple, is from the Eye of the Obsever, 207 feet, and above 3 quarters.

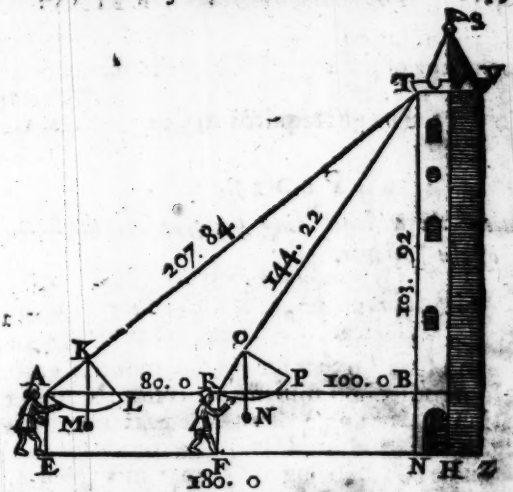
PROBL. III.

Some part of the distance being given, to find the Hypotenuse.

LEt the part of the distance given, be A R or E F, 80 feet, and it is required to find the Hypotenuse T R (which is the Hypotenuse to the triangle R B *T*) First find the other angles thus.

A *T* 207. 84 ⅀ Sum 287. 84	2,45915
A R 80. 90 ⅀ Diff. 127. 84	2,10667
Tang. ½ sum of the oppos. angle 75 deg.	10,57195
	12,67862
Tang. ½ difference 58 53 52	10,21672
Sum 133 53 53 = Angle A R *T*,	
Whose Complement 46 6 8 = Angle *T R B*	

Then



Then by the 4 Probl. of the same Sect. for *RT*.

As the sine of the an. *ART* 133d. 53m. 52 se.	9,85768
To A T 207, 84	2,31774
So the sine of the angle T A *R* 30 deg. 0 min.	9,69897
	12,01671
To the Hypotenuse R T 144, 22	2,15903

PROBL. IV.

Some part of the Distance being given, to finde the Altitude

REtaining the angles and Hypotenuse found by the former Probleme, I say, (by the second Probleme, of the second Booke, sect: 1.)

As

As the Radius 90. deg. 10,00000
To the ſine of the angle TRB 46,d.6 m.8 ſe 9,85768
So T R 144. 22 2,15903
To B T the height required 103. 92 2,01671

PROBL. V.

Part of the Diſtanse being given, to finde the Remainer of the Diſtance.

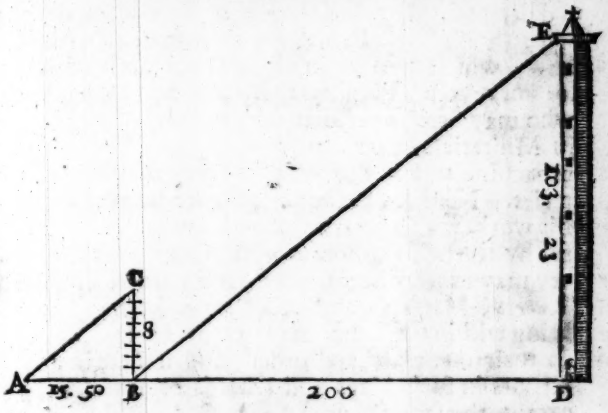
LEt part of the diſtance given be A B 80 feet, and the remainer of the diſtance R B cannot be meaſured, either for water, mooriſh ground, or ſome other impediments; therefore at my firſt ſtation A, the angle of altitude was obſerved, 30 deg. 0 min. and at R 46 deg. 6 min. 8 ſe. ſo that the angle R T B (being the Complement of the angle T R B) is 43 deg. 53 min. 52 ſe. which known, I ſay

As the Radius 10,00000
To the ſine of the angle BTR 43d. 53m, 52ſe. 9,84097
So the Hypotenuſe T R 144. 22 2,15903
To the remainer of the diſtance R B 100 2,00000

PROBL. VI.

To find the height of a Tower, Steeple, or a Turret by a plain ſtaff ſet upright where the Sun or Moon doth ſhine.

SUppoſe A B be a Turret, Tree, or Steeple, whoſe height is required to be found by the ſhadow it makes on levell Ground; therefore ſetting up



up a ſtaff of 8 feet in length as B C, the ſhadow which it makes from B to A, is 15 feet and a half. And becauſe the ſhadow of the Tower from the Baſe thereof to B is 200 feet, I ſay, as the ſhadow of the ſtaff, is to the height of the ſtaff, ſo is the ſhadow of the Turret, to the height of the Turret.

The Operation may either be performed by Naturall Numbers, or thus by Logarithms.

As A B 15. 50	1,19033
To B C 8 feet	0,90309
So B D 200 feet	2,30103
	3,20412
To E D 103. 23 *feet*	2,01379

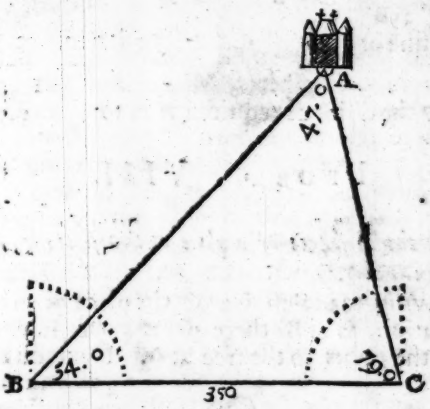
To the former Problems of *Altimetria*, I ſhall annex a Probleme or two of *Longimetria*, whereby the diſtance of any ſuch places upon the Earth, that lye within the view of the Eye, may be found out and

and determined by th eſolution of right-lined Triangles, and alſo by Projection, as we ſhall afterward ſhew; which will be moſt excellent and uſefull for Surveyors, Engineers, Miners, and ſuch like, who may hereby performe many notable exploits in Militarie-affaires, as ſpringing of Mines, approaching to Forts and Caſtels, and making Batteries. Neither can the Geographer be perfect in his work, without a competent knowledge therein, for by the help thereof, a whole Region or Country may exactly be deſcribed, and all ſuch Towns, Rivers, Marſhes, and other remarkeable places lying within the ſame, may hereby be laid down in their due place and order; and if there be any errours in ſuch Maps and Chards as are already extant, they may hence be corrected, as the ingenious Artiſt will ſooner find by practice, then by many words, and therefore I ſhall not make any tedious preamble, but ſhall come to that which I intend upon this matter.

PROBL. VII.

The Intervall of two ſtations being given, with the quantity of the angle at each ſtation, to find the Diſtance.

SUppoſe from ſome private place, as at B, you eſpie a Caſtle, but for fear of Gun-ſhot, Mooriſh-ground, or ſome other impediments, you cannot have an opportunity to make your ſecond ſtation, in any open place, but are forced to make it in ſome other



other ſecure place, as at C. In this caſe having planted your Inſtrument at B, and directed the ſights to *A* and *C*, take the quantity of the angle *A B C* 54 deg. 0 min. and the quantity of the angle *A C B*, 79 deg. 0 min. which known, with the intervall of the two ſtations B and C, 350 yards, I ſay by the 4 Probleme of the ſecond Book, Sect. 2.

1. To find *B A*.

As the ſine of the angle *B A C* 47 d. 0 m.	9,86413
To *B C* 350 yards	2,54407
So the ſine of the angle *A C B* 79 d. 0 m.	9,99154
	12,53601
To the Diſtance *B A* 469. 77	2,67188

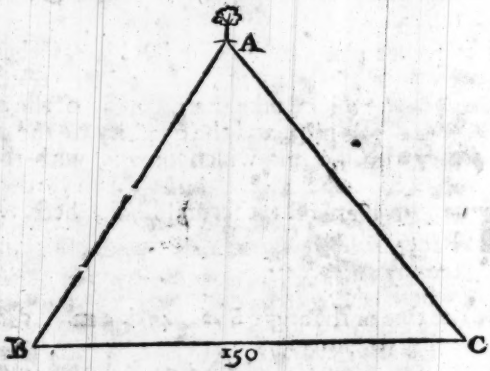
2. To find *C A*.

As the ſine of the angle *B A C* 47 d. 0 m.	9,86413
To *B C* 350	2,54407
So the ſine of the angle *A B C* 54 d. 0 m.	9,90796
	12,45203
To *A C* the diſtance required 387. 17	2,58790

PROBL. VIII.

To take the Diſtance of a place at two ſtations, by the Plain-Table.

HAving made choice of the place of your firſt ſtation, as at B, there plant your Table, and direct the ſights to the tree at A. Next direct the



ſights of your index to the place of the ſecond ſtation at C, and from B, ſtrike lines towards A and C; then with your Chain, meaſure the Interval between the two ſtations B and C 150 yards. Then pla yo

your Table at C, where you may ſee both the tree, and your firſt ſtation; and ſcrewing faſt the Table, lay the index upon the line B C, which done, turn the Table gently about, till through the ſights you ſee the place of your firſt ſtation at B, then fixing the Table, turn the index about upon the point C, and directing the ſights thereof to A, ſtrike a line by the edge of the Ruler, and where it interſects the line *A B* (as at *A*) there make a mark, then open your Compaſſes to the extent *B A*, which being applyed to the ſame Scale by which you laid down the ſtationary-diſtance, you ſhall find the diſtance *B A* 124 yards, and the diſtance *C A* 135 yards.

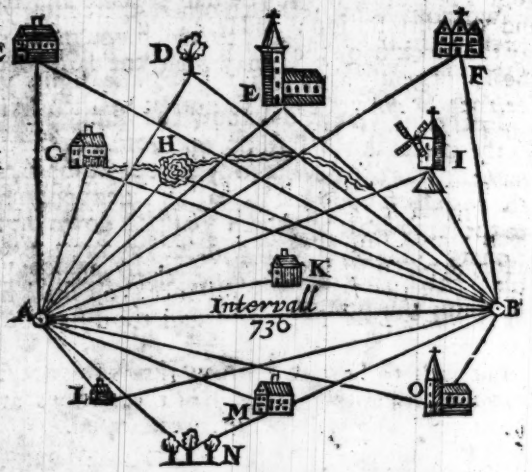
But it is to be noted (in works of this nature) that the larger the intervall of the ſtations are, the more exactly will the diſtance be found.

PROBL. IX.

To take the Diſtance of divers places remote from you by the help of two ſtations.

THis Probleme ſerveth chiefly to deſcribe upon Paper or Parchment, all the moſt eminent and remarkable places in a Countrey, Town, or City, whereby a *Map* thereof may be exactly made, as with a little practice you may ſoon perceive.

Upon ſome hill, or high piece of ground, make choice of two ſtations, as *A* and *B*, from whence you may plainly diſcerne all the principall places which you intend to deſcribe in your Map. Then at *A* plant your Table, and direct the ſights of the index



index to B, which done (your Table being fixed, ſet your index upon the point A, upon which, turning it about, direct the ſights ſeverally to C G D H E F I K M N L, to every of which places, ſtrike a line by the edge of the Rule. Next meaſure the ſtationary-diſtance A B, which you ſhall find 730 Perches, or two miles and 90 Perches, which you are to place down from A to B, by the aſſiſtance of your Scale and Compaſſes; then planting the Table at B, lay the index upon the ſtationary-line B A, and then turn the Table, till through the ſights, you eſpie the place of your firſt ſtation at A, in which poſiture (the Table ſtanding fixed) direct your ſights again from B towards all the former points, and where theſe, and the lines drawn

drawn from A interſect each other, there muſt you deſcribe the ſeveral places to which you made obſervation, where you may write the name of the place as you ſee convenient.

Laſtly, If you would know the diſtance of any of the places thus deſcribed, one from another, you have no more to do, but to open your Compaſſes to the two places upon the Paper, and then applying it to the ſame Scale by which you laid down the ſtationary diſtance, it will, without any further trouble, effect your deſire. And thus much briefly, touching this matter.

The End of the Eight Book.

S

The Art of SURVEYING

The Ninth Book.

ALthough we have not hitherto treated of Sphæricall-Triangles (as being of little or no use in the former parts of this Book) yet because the distance of places upon the Terrestriall-Globe, cannot precisely be surveyed & determined without some knowledge therein, we shall here lay down some compendious Problems performed thereby, which no doubt will be very requisite and necessary for my Surveyor to make use of, for by the help and assistance thereof, he may both speedily and exactly, finde the distance of any Cities and places situate upon the superficies of the Earth, as they are to be reckoned in a Sphæricall-line, which I have here added, in regard that in the former Books I have already shewed how the distance of any places that lye under the eye, may be discover'd, and truly found out by the solution of right-lined Triangles; so

ſo that now there is not a place either near, or far remote, but (if the Longitude and Latitude be truely known) its bearing and diſtance may alſo be known and computed (and that with much celerity and exactneſſe) as we ſhall demonſtrate in the enſuing Problems, which no doubt will yield abundance of delight and recreation to all, though more eſpecially to ſuch, as have not yet taſted of things of this nature, wherein I ſhall in as plain a *Method* as may be, (though with ſome brevity) deliver what I intend upon this ſubject, and referre ſuch as are more curious, and delight in varieties to my *Aſtronomia Brittanica*. But firſt it will not be unfit, to ſhew what the Longitude and Latitude of a place is, and how the diſtance of one place from another, is repreſented to the eye, according to the projection of the Sphere.

1. The Longitude of a place is the diſtance thereof from the Fortunate Iſlands beyond *Portugall*, which is called the Primary-Meridian, from whence the Longitude of all places upon the Earth, are numbred in the Equinoctiall towards the Eaſt.

2. The Latitude of a place is the diſtance thereof from the Equinoctiall Circle, which is numbred in the Meridian towards one of the Poles.

3. The diſtance of two places is an arch of a great Circle paſſing through both the ſaid places and is the ſhorteſt ſpace between them upon the Earths ſuperficies.

Although the Longitude of a place may be had and found out ſeverall wayes, yet the moſt exact of all other is by the Moons-Eclipſe. As ſuppoſe the Moons Eclipſe ſhould begin at *London*, at 8 a clock, and 55 min. at night, and the ſame evening it is obſerved to begin at *Rome*, at 9 a clock and 46

min. the difference will be 51 min. or 12 deg. and 45 min. which added to the Longitude of *London* 24 deg. 20 min. pointeth out the Longitude of *Rome*, 37 deg. and 5 min.

The Latitude of a place may be taken any day in the year, by the height of the Sun at noon, and by the help of his Declination; for if the Sun have South Declination, adde to the same his Altitude observed by a Quadrant, being corrected by Parallax and Refraction; or if he have North Declination, substract the same from his Altitude observed, and you shall have the Complement of the Elevation of the Pole.

Example. The 10 day of *Aprill* 1661, the Sun at noon, (according to my Ephemerides) was in 0 deg. 52 min. of *Taurus*, having North-Declination 11 deg. and 49 min. at which time, his true meridian-altitude was observed here at *Luffenham* to be 49 deg. and 9 min. therefore, according to the Rule, because he hath North-Declination, I substract the Declination out of the Altitude, and there remains 37 deg. 20 min. which is the Complement of the Poles Elevation.

But because there are already extant, particular Catalogues of the Longitude and Latitude of most Cities and places in the World, we shall not further insist upon this business, but shall in the following Problems shew how to investigate exactly the itinerarie distance of any two places upon the Globe of the Earth.

PROBL.

PROBL. I.

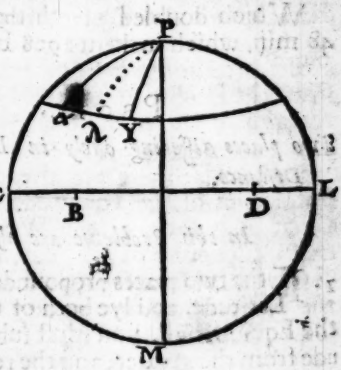
Two Places differing onely in Longitude, to find their distance.

FOr Explanation, observe that in the adjunct Diagram, the outermost Circle marked with the letters P C M L represents the primarie Meridian of the Earth, C D B L the Earths Equinoctiall, P the North pole thereof, M the South pole, &c.

In this Probleme are two Cases.

1. If both the places are under the Equinoctiall, then the difference of their Longitude is the distance required:

Example. Suppose B to be the Island of S. *Thomas*, which hath Longitude 33 deg. and 10 min: & D the Island of *Sumatra*, whose Longitude is 137 deg. 10 min. therefore the difference of their Longitude 104 deg. converted into English miles, by allowing 60 to one deg. giveth 6240 for their distance.



2. If the two places given are not situate under the Equinoctiall, but lye under some parallel be-

tween the Equinoctiall and one of the Poles, then take this Example.

In this Diagram, let α represent the City of *Compostella* in *Spain*, whose Latitude is 43 deg. and γ the City of *Constantinople*, which hath the same Latitude, but differs in Longitude 44 deg. wherefore to find their distance α γ, take the half difference of their Longitude α λ, or λ γ 22 deg. Then in the Rectangled Triangle α λ P we have known (1.) α P the Complement of the Poles Elevation, 47 deg. (2.) the angle α P λ the half difference of the Longitude of the said Cities 22 deg. (3.) P λ α a right angle 90 deg. hence to find α λ, I say,

As the Radius 90 deg.	10,
To the sine of the angle α P λ 22 deg.	9,57357
So the sine of P α 47 deg.	9,86413
To the sine of α γ 15 deg. 54 min.	9,43770

Which doubled giveth their distance 31 deg. 48 min. which maketh 1908 English miles.

PROBL. II.

Two places differing onely in Latitude, to find their Distance.

In this Probleme are also two Cases.

1. IF the two places propounded, do differ only in Latitude, and lye both of them on one side of the Equinoctiall, you must substract the lesser latitude from the greater, and the residue is the distance required.

Suppose therefore that the place X have Latitude 22 deg. 30 min. North, and the place O 45 deg. 50 min. Now the difference is 23 deg. 20 min.

which

which being converted into miles, giveth the distance of the said two places 1400 miles.

2. But if the two places propounded lye the one on the North side the Equinoctiall, and the other on the South side, then you are to adde the two Latitudes together, and the sum will give their true distance.

Example, Suppose the place Q have 45 deg. 50 min. North Latitude, and the place Z have 21 deg. South Latitude, therefore their aggregate 66 deg. 50 min. being converted into miles, gives their distance 4010.

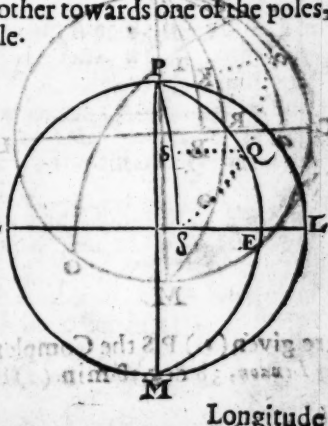
PROBL. III.

Two Places being given, which differ both in Longitude and Latitude, to finde their distance.

In this Probleme are also two Cases.

1. IF one of the Places is situate under the Equinoctiall, and the other towards one of the poles, then take this Example.

Let ♑ represent the City of *Arim* (which of the *Arabian* Astrologers is called the middle of the World) whose Longitude is 109 deg. 5 min. & is situate right under the Equinoctiall. And let Q represent the City of *Quinsai*, which hath

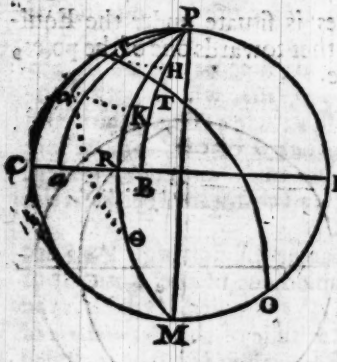


Longitude 152 deg. 20 min. & North Latitude 40 deg. the distance of which two places is shewed by the Arch ♌ Q. Wherefore in the Rectangled Triangle ♌ E Q are given (1.) ♌ E the difference of their Longitude, 43 deg. 15 min. (2.) E Q the Latitude of *Quinsai*, 40 deg. (3) ♌ E Q 90 deg. Hence their distance ♌ Q is inquired.

As the Radius 90 deg.	10,00000
To the Cosin. of E Q 40 deg.	9,88425
So the Cosin. of ♌ E 43 deg. 15 min.	9,86235
To the Cosin. of ♌ Q 56 deg. 5 min.	9,74660

Now the arch ♌ Q being reduced into miles, maketh 3365 *Italian* miles, which is the distance between *Quinsai* and *Arim*.

2. But if both the Places are situate without the Equinoctiall, their distance is to be sought by the solution of a Sphæricall Triangle Obliquangle, as we shall demonstrate in the two following Examples.



Example 1. Let us suppose S to represent *London*, whose Latitude ♌ S is 51 deg. 32 min. and T *Hierusalem*, whose Latitude is 32 deg. 10 min. Now the difference of the Longitudes of these two Cities is 45 deg. 30 min. Wherefore in the Obliquangled Triangle S P T are given (1.) P S the Complement of the Latitude of *London*, 38 deg. 28 min. (2) P T the Complement

of the Latitude of *Hierusalem*, 57 deg. 50 min. (3.) the included angle S P T 45 deg. 30 min. then to find their distance S T; I say, first

As the Radius	10,00000
To the tangent of P S 38 deg. 28 min	9,90008
So the Colin of the angle S P T 45 d. 30 m.	9,84566
To the tangent of P H 29 deg. 7 min.	9,74574

(1)

	deg.	*min.*
From the Arch P T	57	50
Substract P H	29	7
Remains T H	28	43

(2)

As the Colin. of P H 29 deg. 7 min.	9,94255
To the Colin. of P S 38 deg. 28 min.	9,89374
So the Colin. of H T 28 deg. 43 min.	9,94298
	19,83672
To the Colin. of S T 38 deg. 12 min.	9,89537

Which maketh 2291 miles, for the distance of *Hierusalem* from *London*.

Example 2. Again, let us suppose the point *a* to represent the City of *Compostella*, which hath Longitude 15 deg. 20 min. Latitude 43 deg. 0 min. and let *b* represent the *Promontorie* of *Good-hope*, whose Longitude is 49 deg. 20 min. Latitude 35 deg. South. And lastly let *a b* the distance between the two places be inquired.

Wherefore in the triangle Obliquangle P *a b* are given (1) P *a* the Complement of the Latitude of *Compostella* 47 deg. (2) P *b* 125 deg. (which is the aggregate of R *b* the Latitude of the *Promontorie* of *Good-hope*, 35 deg and P R 90 deg.) (3) the included angle *a* P *b* 34 deg. which is the difference of the Longitudes of the said two places. Hence their distance

distance α^{θ} may be found, as before

1.

As the Radius 90 deg.	10,
To the tangent of P α 47 deg.	10,03034
So the Cosin of the angle α P θ 34 degrees	9,91857
To the tangent of P K 41 degrees 38 min.	9,94891

	deg.	*min.*
From the arch P θ	125	0
Substract P K	41	38
Rests K θ	83	22

2.

As the Cosin of P K 41 deg 38 min	9,87353
To the Cosin of P α 47 deg 0 min	9,83378
So the Cosin of K θ 83 deg 22 min	9,06295
	18,89673
To the Cosin of α θ 83 deg 57 min	9,02320

Whereunto answereth 5037 *Italian* miles, which is the distance required.

The End of the Ninth Book.

The Art of SURVEYING

The Tenth Book.

IN the former Books are conteined such *Problems Geometricall*, as are most necessary for every Surveyor to understand and practice. And now to the end he may elevate and raise his eyes (from off the Earth) to the contemplation of those glorious Bodies, the *Sun*, *Moon*, and *Stars*, I shall here, in the last place, give him a brief Survey (as it were) of the first *Rudiments* of *Astronomy*, whereby he may (in his vacant hours) get a competent knowledge of such conclusions, as are most meet and requisite for his use and purpose: And first of all (that I may proceed in an orderly method) I shall give you a brief and succinct explanation of the severall Circles of the *Sphere*, and then shew how to resolve and perform artificially, all the most

most use full and common Problems thereof, together with some *Problems* of *Horologiography*, shewing how to calculate and describe the *Horizontall*, and all sorts of *Mural Sun Dials*, whether *Direct* or *Declining*, according to the projection of the *Sphære*: to which we shall annex sundry other Rules and Tables, both to find the true hour of the *Day* and *Night*, by the *Sun*, *Moon*, and *Stars*.

An Explanation of the Circles of the Sphære.

First I shall begin with the *Equinoctiall*, otherwise called the Æquator, which is the chief and principall Circle in the *Sphere*, dividing the Heavens in the middle between the two Poles, to which, when the Sun cometh, he maketh the dayes and nights of an equall length throughout the World.

2. The Meridian is a great Circle passing through the *Poles* of the *World* and the *Zenith* of the place, unto which place when the *Sun* cometh it is noone. The number of Meridians are as many as there can be imagined verticall points, from the West to the East, whereof *Ptolomie* and other *Cosmographers* have described 180.

3. The *Verticall-point* or *Zenith*, is the point directly over head, and is the centre or pole of the *Horizon*.

4. The *Nadir* is the opposite point.

5. The *Horizon* is a great Circle dividing the visible part of the Heavens from the invisible; namely the superiour *Hemisphere* from the inferiour.

6. The *Zodiack* is a great circle broad and slopewise, described upon its proper poles, bearing the 12 *Signes*, and divideth the Æquator into two equall parts, in the middle whereof is a line called the

the *Ecliptic*, or the way of the *Sun*, from which the Latitude of the Planets are numbred both Northward and Southward: The circumference of this circle contains 360 degrees, which is divided into twelve equall parts called Signes, every one representing some living creature, either in shape or property. Again, every Sign containeth 30 degrees, every degree 60 minutes, every minute 60 seconds, and every second 60 thirds, &c:

7. The *Solstitiall-Colure* is a great circle drawn through the poles of the World, the poles of the Zodiack, and the Solstitiall points of *Cancer* and *Capricorne*:

8. The *Equinoctiall-Colure* is a circle passing by the poles of the world, and the Equinoctiall-points, which intersects the Colure of the Solstices at right angles in the poles of the world.

9. The *Tropick* of *Cancer* is a lesser circle of the Sphære equally distant from the Equinoctiall Northward, 23 degrees, 31 minutes, 30 seconds, wherein when the Sun is, he is entring *Cancer*, making his greatest Northern Declination.

10. The *Tropick* of *Capricorn* is also a lesser circle equally distant from the Equinoctiall Southward, 23 degrees, 31 minutes, 30 seconds, to which when the Sun cometh (which is about the tenth of *December*) he maketh his greatest Southern Declination.

11. The *Circle Artick* is so far distant from the North pole of the World, as the *Tropick* of *Cancer* is from the Equinoctiall, to which its parallel; and so much are the poles of the Zodiac distant from the poles of the world.

12. The *Circle Antartick* is also parallel to the Equinoctiall, and is distant from the South pole, so much-

much as the circle *Artick* is from the North pole, viz. 23 degrees, 31 minutes, 30 seconds.

13. *Azimuth*, or *verticall circles* passe through the *Zenith*, and intersect the Horizon with right angles, wherein the distance of the Stars, from any part of the Meridian are accounted, which is called the *Azimuth*.

14. *Circles* of *Altitude* (called the Almicantherat) are circles parallel to the Horizon, and intersect the verticall circles with right angles, which are greatest in the Horizon, and meet together in the Zenith of the place; in which circles, the Altitude of the Stars above the Horizon, are accounted.

15. *Circles* of *Position* passe by the common Sections of the Meridian and Horizon, and by the centre of the Star.

16. *Circles* of the *Celestiall Houses*, are such as divide the Heavens into twelve equall parts.

17. *Circles* of *Declination* are drawn through the poles of the world, and points of the Æquator.

18. *Circles* of *Latitude* are those that pass through the poles of the Ecliptic, and the Body of the Star.

19. The *Axis* (or Axeltree) of the world is a supposed streight line drawn from the North pole to the South pole, about which the motions of the Stars and Planets are performed.

20. The *Elevation* of the *Pole* is the height thereof above the Horizon, which is equall to the distance between the *Zenith* and the *Equinoctiall*, whose complement is equall to the distance of the *Zenith* from the *North pole*, or to the Elevation of the *Equator* above the *Horizon*.

These Circles which are of most use, I here thought good to insert, for if these be not perfectly known

my Reader cannot well understand the following Problems of the Sphære that depend thereupon.

PROBL. I

To calculate the Suns true place.

FOrasmuch as the true place of the Sun is commonly required in most Mathematicall Operations, so that very few Problems of the Sphære can aright be performed, without the true knowledge thereof, we shall (before we enter thereupon) shew how you may calculate his true place from the *Earth*, according to our Hypothesis and Tables in *Astronomia Brittanica*.

First enter the Table of the middle motion of the Sun, and write out the *Epocha* next going before the time given, under which set the motions distinctly belonging to the years, moneths and dayes, and hours and minutes; if any be (onely in the *Bissextile* year after *February*, a day is to be added to the number of the dayes given) then adding them all together, the Sum will be the middle motion of the Sun for the time given.

Example.

Let the time given be the tenth of *Aprill*, 1665. at noon, at which time the Suns place is to be inquired.

Time given	*Longit.* ☉ S	D	′	″	*Apog* ☉ S	D	′	″
The *Epocha* 1661	9	20	24	49	3	6	45	5
Years includ.	4	0	0	1	48			4	7
Aprill	2	28	42	30				15
D. 10			9	51	23				2
Sum mid. motion	0	29	0	30	3	6	49	29

2. Sub-

2. Substract the *Apogeum* of the *Sun* from his *mean Longitude*, and the residue will be his mean *Anomalie*.

Example.		S	D	′	″
The Suns mean Longitude		0	29	0	30
The Apogeum.	Substract.	3	6	49	29
The Suns Anomalie.		9	22	11	1

3. With the Suns Anomalie enter the Table of his Equation, with the sign on the head, and the degree descending on the left hand, if the number thereof be under 6 sig. but if it exceed 6 sig. enter with the sign at the bottom, and the degree ascending on the right hand, and in the common angle, you have the Equation answering thereunto, only you must remember to take the *Proportionall Part*, if need require.

Example.	D	′	″
In the Table, the Equa. answering to 22 d. is	1	52	22
The Equation answering to 23 deg. is	1	51	29
Their difference	0	53	

Then I say, if one degree or 60 minutes, give 53 seconds, what shall 11 minutes of the Anomalie give? Multiply 53 by 11, the product is 583, which divided by 60, the Quotient will be 9″ $\frac{43}{60}$, and because the Equation decreaseth, I substract it from 1 d. 52′ 22″, and there remaineth 1 d. 52′ 12″ for the true Equation desired, which (according to the Title) being added to the Suns mean Longitude, giveth the true place of the Sun required.

Example		S	D	′	″
The Suns mean Longitude		0	29	0	30
Equation	adde		1	52	12
The Suns true Longitude		1	0	52	42

Therefor

Therefore the true place of the Sun is in 0 deg. 52′ 42″ of *Taurus*.

Another Example.

In the year 1583 *March* 14 at noon, in the Meridian of *Uraniburg* in *Denmark*, Noble *Tycho Brahe* most accurately observed the Suns true place in 3 degrees, 17′ 4c″ ♈.

The time at *London* was 1583 *March* 13 day 23 ho. 8′.

The Calculation.

Time given		Longit. ☉ S	D	′	″	Apog ☉ S	D	′	″
The Epocha	1581	9	19	48	55	3	5	22	55
Years add.	2	11	29	31	20			2	4
	March	1	28	9	11				10
	Days 13		12	48	48				2
	Ho. 23			56	40				0
	Min. 8				20				0
Suns mean Motion		0	1	15	14	3	5	25	11
Apogeum Sub:		3	5	25	11				
Anomaly of ☉		8	25	50	3				
Equation add.			2		2 51				
Suns true place observation.		♈	3	18	5	agreeing to			

A Table of the Suns Mean Motion.

The Æpoche or Radices

Year	Longit ☉ S D M S	Apog. ☉ S D M S
Ch. 1	9 07 59 51	2 08 20 03
1581	9 19 48 55	3 05 22 55
1601	9 19 57 54	3 50 43 28
1621	9 20 06 52	3 06 04 00
1641	9 20 15 51	3 06 24 33
1661	9 20 24 49	3 06 45 05
1681	9 20 33 48	3 07 05 38

☉ mean Mot. in years above 20

20	0 00 08 59	0 00 20 33
40	0 00 17 57	0 00 41 05
60	0 00 26 56	0 11 01 38
80	0 00 35 54	0 11 22 10
100	0 00 44 53	0 11 42 43
200	0 02 29 45	0 03 25 26
300	0 02 14 38	0 05 08 08
400	0 02 59 31	0 06 50 51
500	0 03 44 23	0 08 33 34
600	0 04 29 16	0 10 16 17
700	0 05 14 09	0 11 59 00
800	0 05 59 01	0 13 41 42
900	0 06 43 54	0 15 24 25
1000	0 07 28 47	0 17 07 08
2000	0 14 57 34	1 04 14 15
3000	0 22 26 21	1 21 21 22
4000	0 29 55 08	2 08 28 30
5000	1 07 33 55	2 25 35 37
6000	1 14 52 42	3 12 42 44

☉ meã Mot. in Ye. und. 20

Year	Longit. ☉ S D M S	Ap. ☉ M S
1	11 29 45 40	1 02
2	11 29 31 20	2 04
3	11 29 16 59	3 05
B 4	00 0 01 48	4 07
5	11 29 47 28	5 08
6	11 29 33 07	6 10
7	11 29 10 47	7 12
B 8	00 0 03 35	8 13
9	11 29 49 15	9 14
10	11 29 34 55	10 16
11	11 29 20 35	11 18
B 12	00 0 05 23	12 20
13	11 29 51 03	13 21
14	11 29 36 43	14 23
15	11 29 22 23	15 25
B 16	00 0 07 11	16 26
17	11 29 52 51	17 28
18	11 29 38 31	18 29
19	11 29 24 10	19 31
B 20	00 0 08 59	20 33

Suns mean Mot. in Moneth

January	00	00	00	00	00	00
Februar	01	00	33	18	00	05
March	01	28	09	11	00	10
Aprill	02	28	42	30	00	15
May	03	28	16	39	00	20
June	04	28	49	58	00	25
July	05	28	24	07	00	31
August	06	28	57	25	00	36
Septem	07	29	30	44	00	42
October	08	29	04	54	00	[illegible]
Novemb	09	29	38	12	00	[illegible]
Decemb	10	29	12	22	00	[illegible]

A Table of the Suns Mean Motion.

Dais	Longit ☉ SD M S	Ap H m.sl		Long ☉ D M S	m	Lo S ☉ M
1	0 0 59 08	0 0	1	0 02 28	31	1 1
2	0 1 58 17	0 0	2	0 04 56	32	1 19
3	0 2 57 25	0 0	3	0 07 24	33	1 21
4	0 3 56 33	0 1	4	0 09 51	34	1 24
5	0 4 55 42	0 1	5	0 12 19	35	1 26
6	0 5 54 50	0 1	6	0 14 47	36	1 29
7	0 6 53 58	0 1	7	0 17 15	37	1 31
8	0 7 53 07	0 1	8	0 19 43	38	1 34
9	0 8 52 15	0 1	9	0 22 11	39	1 36
10	0 9 51 23	0 2	10	0 24 38	40	1 39
11	0 10 50 31	0 2	11	0 27 06	41	1 41
12	0 11 49 40	0 2	12	0 29 34	42	1 43
13	0 12 48 48	0 2	13	0 32 02	43	1 46
14	0 13 47 57	0 2	14	0 34 30	44	1 48
15	0 14 47 05	0 2	15	0 36 58	45	1 51
16	0 15 46 13	0 3	16	0 39 25	46	1 53
17	0 16 45 22	0 3	17	0 41 53	47	1 56
18	0 17 44 30	0 3	18	0 44 21	48	1 58
19	0 18 43 38	0 3	19	0 46 49	49	2 01
20	0 16 42 47	0 3	20	0 49 17	50	2 03
21	0 20 41 55	0 3	21	0 51 45	51	2 06
22	0 21 41 03	0 4	22	0 54 13	52	2 08
23	0 22 40 12	0 4	23	0 56 40	53	2 11
24	0 23 39 20	0 4	24	0 59 08	54	2 13
25	0 24 38 28	0 4	25	1 01 34	55	2 18
26	0 25 37 37	0 4	26	1 04 04	56	2 18
27	0 26 36 45	0 4	27	1 06 32	57	2 20
28	0 27 35 53	0 5	28	1 09 00	58	2 23
29	0 28 35 02	0 5	29	1 11 27	59	2 25
30	0 29 34 10	0 5	30	1 13 55	60	2 28
31	1 0 33 18	0 5	M	*m.se. th.*	*se.*	*se th*

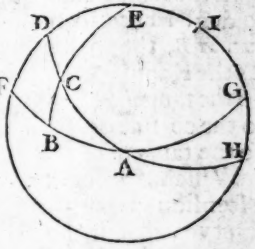
A Table of the Suns Æquation.

Degrees	Sig 0 Æ sub d. m. se	Sig 1 Æ sub d. m. se	Sig 2 Æ sub d. m. se	Sig 3 Æ sub d. m. se	Sig 4 Æ sub d. m. se	Sig 5 Æ sub d. m. se	Degrees
0	0 0 0	0 59 32	1 44 28	2 2 54	1 48 23	1 3 26	30
1	0 2 5	1 1 21	1 45 34	2 2 56	1 47 20	1 1 32	29
2	0 4 9	1 3 10	1 46 38	2 2 56	1 46 15	0 59 37	28
3	0 6 13	1 4 57	1 47 41	2 2 55	1 45 9	0 57 40	27
4	0 8 16	1 6 42	1 48 40	2 2 52	1 44 1	0 55 42	26
5	0 10 19	1 8 26	1 49 38	2 2 47	1 42 50	0 53 43	25
6	0 12 22	1 10 9	1 50 34	2 2 39	1 41 37	0 51 43	24
7	0 14 25	1 11 51	1 51 29	2 2 29	1 40 22	0 49 42	33
8	0 16 28	1 13 32	1 52 22	2 2 17	1 39 4	0 45 39	22
9	0 18 30	1 15 11	1 53 13	2 2 2	1 37 45	0 45 35	21
10	0 20 32	1 16 49	1 54 1	2 1 46	1 36 24	0 43 31	20
11	0 22 35	1 18 26	1 54 43	2 1 29	1 35 3	0 41 26	19
12	0 24 37	1 20 2	1 55 31	2 1 7	1 33 39	0 39 20	18
13	0 26 39	1 21 36	1 56 14	2 0 44	1 32 2	0 37 14	17
14	0 28 41	1 23 9	1 56 55	2 0 18	1 30 44	0 35 6	16
15	0 30 42	1 24 41	1 57 34	1 59 49	1 29 13	0 32 58	15
16	0 32 43	1 26 11	1 58 10	1 59 19	1 27 41	0 30 50	14
17	0 34 44	1 27 40	1 58 44	1 58 47	1 26 7	0 28 41	13
18	0 36 43	1 29 8	1 59 16	1 58 12	1 24 32	0 26 31	12
19	0 38 41	1 30 34	1 59 46	1 57 35	1 22 56	0 24 21	11
20	0 40 38	1 31 58	2 0 14	1 56 56	1 21 18	0 22 10	10
21	0 42 35	1 33 20	2 0 40	1 56 14	1 19 38	0 19 59	9
22	0 44 31	1 34 41	2 1 4	1 55 30	1 17 56	0 17 48	8
23	0 46 27	1 36 0	2 1 26	1 54 44	1 16 12	0 15 36	7
24	0 48 22	1 37 17	2 1 46	1 53 56	1 14 26	0 13 23	6
25	0 50 16	1 38 33	2 2 3	1 53 5	1 12 40	0 11 10	5
26	0 52 9	1 39 48	2 2 18	1 52 12	1 10 52	0 8 57	4
27	0 54 1	1 41 1	2 2 30	1 51 18	1 9 2	0 6 43	3
28	0 55 52	1 42 12	2 2 40	1 50 21	1 7 11	0 4 29	2
29	0 57 42	1 43 21	2 2 48	1 49 23	1 5 18	0 2 15	1
30	0 59 32	1 44 28	2 2 54	1 48 23	1 3 26	0 0 0	0
	adde	*adde*	*adde*	*adde*	*adde*	*adde*	
	Sig 11	Sig 10	Sig 9	Sig 8	Sig 7	Sig 6	

PROBL. II.

The Suns place and greateſt Declination being given, to finde the Declination of any point required.

IN this Diagram let D F H G repreſent the ſolſtitiall Colure, *F A G* the Equinoctiall, *D A H* the Ecliptic, *A* the point of the vernall Equinox, E C B a Meridian line paſſing through E the pole of the Equator by the centre of the Sun at C, and falling upon the Equator *G A F* at right angles in the point B. Alſo let the angle *D A F* be the Suns greateſt Declination 23 deg. 31 m: *A C* the diſtance of the Sun from the beginning of *Aries*, 30 degrees, and B C the Declination of the point ſought. Wherefore in the rectangled ſphæricall Triangle *A B C*, we have given (1) the Hypotenuſe A C 30 deg. (2) the angle *B A C* 23 deg. 31 min: Hence to find B C, I ſay



As the Radius 90 deg.	10,00000
To the ſine of the angle *B A C* 23 deg. 31	9,60099
So the ſine of *A C* 30 deg.	9,69897
To the ſine of B C 11 deg. 30′	9,29996

Which is the Suns Declination required.

PROBL

PROBL. III.

The Suns greatest Declination and his distance from the next Equinoctiall point being given, to finde his right Ascension.

IN the Triangle *A B C* we have given (as before) (1) the angle of the Suns greatest Declination *B A C* 23 deg. 31 min: (2) the Longitude of the Sun from the next Equinoctiall point ♈ *Aries*, *viz.* A C 30 deg. Hence to finde the right Ascension of the Sun *A B*, the analogie is,

As the Radius 90 deg.	10,00000
To the tangent of *A C* 30 deg: 0 min:	9,76144
So the co-sine of *B A C* 23 deg. 31 min:	9,96233
To the tangent of *A B* 27 deg. 53 min:	9,72377

Which 27 deg: and 53 min: is the *Suns* right *Ascension* in 0 deg. of *Taurus*: But here you are to observe, that if the right *Ascension* of the point sought be in the second Quadrant, ♋♌♍, then you are to take the Complement of the arch found to 180 deg: If it be in the third Quadrant ♎♏♐, adde a Semicircle to the arch found; but in the last Quadrant, substract the arch found from the circle 360 deg. and you shall have the right *Ascension* desired.

Example 2. The Sun in ♌ 60 deg. from the Equinoctiall point ♎:

As the Radius 90 deg.	10,00000
To the tangent of 60 deg.	10,23856
So the co-sine of 23 deg. 31 min.	9,96233
To the tangent of 57 deg. 48 min:	10,20089

Now the Complement hereof to 180 deg. is 122 deg.

deg. 12 min. which is the Suns right *Aſcenſion* in ☌.

Example 3: The Sun in ♏, 30 deg. from the Equinoctiall point ♎.

The work is the ſame as in the firſt Example, therefore to the arch found 27 deg. 53 min. I adde a Semicircle or 180 deg. and the ſum 207 deg. 53 min. is the right Aſcenſion of the Sun ſought in the firſt point of *Scorpio*.

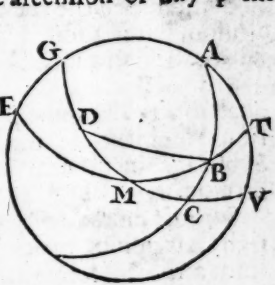
Example 4. The ſun in ♒, 60 deg. from the Equinoctiall point ♈.

The operation is the ſame with the ſecond *Example*, wherefore ſubſtract the arch found 57 deg. 48 min. from the whole circle 360 degrees, there will remain 302 deg. 12 min. which is the Suns right Aſcenſion in the firſt point of *Aquarie*.

PROBL. IV.

The Elevation of the Pole and Declination of the Sun being given, to find the Aſcenſionall difference.

THe Aſcenſionall difference is the quantity or difference between the aſcenſion of any point of the *Ecliptic* in a right Sphære, & the aſcenſion of the ſame point in an oblique Sphære.



In this Diagram, let *AGEV* repreſent the *Meridian*, *EMS* the Horizon, *G M V* the *Equator*, A T the poles *Elevation*, B C the Suns Declination, D B an arch

of the Ecliptic, D C the right *Ascension*, *M B* the *Amplitude* of his rising and setting, *M C* the *Ascensionall* difference. Wherefore in the rectangled sphæricall Triangle *B C M* are known (1) the angle *B M C* the Complement of the Poles Elevation, 37 deg 30 min (2) the Suns Declination B C 11 deg 30 min. Hence to find the *Ascensionall* difference *MC* I say,

As the Radius 90 deg	10 00000
To the cotangent of *B M C* 37 deg 30 min	10,11502
So the tangent of B C 11 deg 30 min	9,30846
To the sine of *M C* 15 deg 22 min	9,42348

PROBL. V.

The Suns Right Ascension, and his Ascensionall difference being given, to find his oblique Ascension and Descension.

TO performe this, you must observe the two following Rules.

1 If the Suns Declination be North, you must substract the Ascensionall difference from the right Ascension, and the residue will be the oblique Ascension, but if you adde them together, the sum will be the oblique descension.

2 If his Declination be South, adde the Ascensionall difference and right Ascension together, the sum will be the oblique Ascension, but if you make Substraction, the remainer will be the oblique Descension.

Suppose the *Sun* be in the first point of *Taurus*, his right Ascension (by the third *Probl.*) is 27 deg 53 min. and his Ascensionall difference (by the 4th)

is 15 deg 22 min. therefore (according to the first Rule, because his declination is North, the difference of them 12 deg 31 min. is the Suns oblique *Ascension*, & the sum of them 43 deg. 15 min. is his oblique Descension.

PROBL. IX.

To finde the time of the Suns rising and setting, with the length of the Day and Night.

FInd the Ascensionall difference by the 4 Problem, which convert into time, allowing 4 min. of an hour for every degree, and 4 seconds for every minute, and the sum of hours and min. so found, is the difference of his rising or setting, before, or after, the hour of six. Therefore when the Sun is in the Northern signes, adde the same to six, and the aggregate is the semidiurnall Arch, or time of the Suns setting; but if he be in the Southern signs, make Substraction.

Thus in the former Example, the Sun being in 0deg. of *Taurus*, having 11 deg. 30 min. North Declination, his Ascensionall difference is found by the 4th Problem, 15 deg. 22 min. which converted into time (as is above shewed) maketh 1 hour, 1 min. 28 se. and because the Sun is in a Northern sign, I adde the same to six hours, and the sum 7 hours, 1 min. 28 sec. is the time of the Suns setting, when he enters *Taurus*, in the Latitude of 52 degrees and a half, whence it follows, that he riseth at 4 a clock, 58 min. and 32 se. that the length of the day is 14 hours, 2 min. 56 se. and the length of the night 9 hours, 57 min. 4 sec.

PROBL.

PROBL. VII.

The Elevation of the Pole, and Declination of the Sun being given, to finde his Amplitude of Rising and Setting.

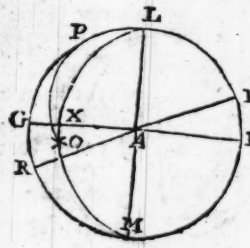
IN the right angled Sphæricall Triangle B C M of the 4th Probl. having the angle B M C the height of the Equator, 37 deg. 30 min. and B C the Suns Declination in 0 deg. of ♉, 11 deg. 30 min. his Amplitude M B may be thus found:

As the sine of B M C 37 deg. 30 min.	9,78445
To the Radius 90 deg.	10,00000
So the sine of B C 11 deg. 30 min.	9,29996
To the sine of M B, 19 deg. 8 min.	9,51551

PROBL. VIII.

The elevation of the Pole, and Declination of the Sun being given, to finde the just quantity of Twylight.

IN this Diagram, let L G M K represent the meridian, G A H the Horizon, L the Zenith of the place, M the Nadir, R A K the Equator, P the North Pole, O the Suns place in the Summer, X O the Depression of the Sun under the Horizon, 18 deg. when the day light is first of all said to break forth:



Now let us suppose in the Latitude of 52 deg. & a half, the Sun be in ♋, having

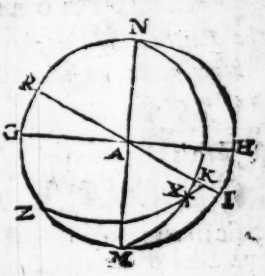
having North Declination 11 deg. 30 min. we shall then have in the Triangle O P L all the sides given, to find the angle L P O, therefore, work thus:

Sides	P O	78 d. 30′	com: of ⊙ decl. S.	9,99119	ad.
	P L	37 30	com. of the Ele. S.	9,78445	
Difference		41 0		19,77564 — 1	
Base L O		180 0		20,00000 — 2	
Sum		149 0	Semisum. 74 d. 30′	9,98391	ad.
Diffe.		67 0	Semidiffe. 33 30	9,74189	
				19,72580 — 3	
				19,95016 — 4	

Arch corresp. 70 d. 46 m. The half 9 97508

Whose double 141. 32 is the angle L P O, which converted into time, maketh 9 hours, 26 min. 8 se. which is the time of Twilight, or Day-light ending, when the Sun enters *Taurus*, in the North Latitude of 52 degrees and a half.

But if it be required to find the time of Twilight when the Sun hath South declination, then subtract the quantity of the Suns depression under the Horizon, 18 deg. from the Quadrant 90 deg. and there will remaine the distance of the Sun from the Nadir 72 deg. which done, the operation will (in a manner) be the same as before.



Example, Let us suppose the Sun be in the opposite point to the former, *viz.* in o m, having South declination 11 deg. 30 min. wherefore in the Triangle *Z X M* we have given

(1) ZX the complement of the Suns declination 78 d. 30 m. (2) *X M* the distance of the *Sun* from the Nadir, 72 d. (3) *Z M* the Complement of the Elevation, 37 d. 30 m. hence to find the angle, XZM the work will ſtand thus.

Sides	Z X 78 d. 30′ com. ⊙ decl.		*S.* 9 99119	add.
	Z M 37 30 com. Eleva.		*S.* 9 78445	
Difference	41 0		19,77564	--- 1
Baſe *X M*	72 0		20,00000	--- 2
Summe	113 0 ſemi.	56 d. 30,	9,92110	add.
Difference	31 0 ſemi.	15 30	9,42690	
			9,34800	— 3
			19,57236	— 4

The corre. arch 37 d. 40 m. The hal. 9,78618

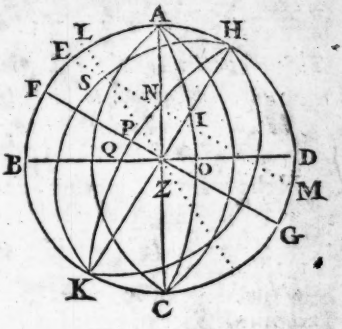
Whoſe double 75 d. 20 m. is the angle *M Z X*, which in time is 5 hours, 1 min. 20 ſec. for the time of day break, when the Sun enters ♍, in the Latitude of 52 deg. and a half.

PROBL. XI.

The Latitude of the place, and the Suns Declination being given, to finde the time when he will be Eaſt or Weſt.

IN this Diagram, let A B C D repreſent the Meridian, F G the Equinoctiall, B D the Horizon, H N K an arch of the Suns Meridian, A Z C the verticall circle of the Eaſt and Weſt points, E N M a parallel of Declination, and laſtly, the angle A H N

A H N, an arch of the Equinoctial; F P is the term desired.



Let us suppose the Sun in ☌ *Gemini*, having North Declination, 20 d. 13 m. and its required to find the time when he will be due East or West in the Latitude of 52 deg. and a half.

Therefore in the rightangled sphæricall Triangle A H N are given, (1) A H the Complement of the Poles Elevation, 37 d. 30′ (2) H N the Complement of the Suns Declination, 69 d. 47, then I say,

As the Radius	10,00000
To the Cotangent of H N 69 d 47 m.	9,56615
So the Tangent of A H 37 d. 30 m.	9,88498
To the sine of A H N 73 d. 35 m.	9,45113

Which reduced into time, giveth 4 hours 54 m. 20 sec. at which moment in the Afternoon, the Sun will be due West; and lastly, if you substract the hours and min. thus found from 12, there remaineth 7 hours 5 min. 40 sec. for the time in the morning when he is due East.

PROBL.

Probl. X.

The Elevation of the Pole, and Declination of the Sun being given, to finde the Suns Altitude when he cometh to be due East or West.

IN the former Diagram, the Suns Altitude when he is due East or West, is shewed by the arch NZ, wherefore in the Triangle Z Q N we have given (1) the Suns Declination in ☌ ♊, 20 deg. 13 min. (2) the angle of the poles elevation N Z Q 52 deg. 30 min, hence to finde his Altitude Z N, I say,

As the sine of the angle Q Z N 52 d, 30 m,	9,89946
To the radius 90 deg,	10,00000
So the sine of the ☉ decli, Q N 20 d, 13 m,	9,53854
To the sine of his altitude Z N 25 d, 49 m,	9,63908

Probl. XI.

The Elevation of the Pole, and Declination of the Sun being given, to finde the Suns Altitude at the hour of six.

IN the diagram of the 9th Problem, we have known, in the triangle A I H (1) the complement of the poles elevation A H 37 deg, 30 min, (2) the complement of the Suns declination H I 69 deg, 47 min, Hence the Hypotenuse A I is inquired, therefore I say,

As the radius 90 deg,	10,00000
To the cosine of H I 69 deg, 47 min,	9,53854
So the cosine of A H 37 deg, 30 min,	9,89946
To the cosine of A I 74 deg, 5 min,	9,43800

Whole

Whose complement I O 15 deg, 55 min, is the *Suns* altitude at the hour of six, when he enters *Gemini*, in the latitude of 52 deg, and a half.

PROBL. XII.

The Latitude of the Place, and Declination of the Sun being given, to finde the Suns Azimuth at the hour of six.

IN the rightangled sphæricall triangle A H I of the last diagram, we have known (1) A H the complement of the poles elevation 37 deg, 30 min, (2) H I the complement of the Suns declination 69 deg, 47 min, Hence to finde the azimuth of the Sun at the hour of six, represented by the angle H A I, I say,

As the radius 90 deg,	10,00000
To the sine of A H 37 deg, 30 min;	9,78445
So the cotangent of H I 69 deg, 47 min,	9,56615
To the cotangent of H A I 77 deg, 22 min,	9,35060

Which is the Azimuth of the *Sun* from the north part of the meridian, at the hour of six, when he enters *Gemini*, in the North latitude of 52 deg, and a half.

PROBL.

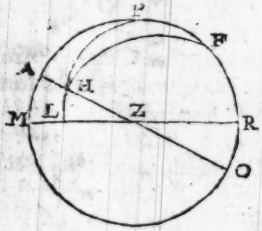
PROBL. XIII.

The Elevation of the Pole, the Declination of the Sun, and his Distance from the Meridian being given, to finde the Suns Altitude at any time assigned.

In this Probleme are three Cases.

1 *If the Sun be in the first point of* Aries *or* Libra.

IN this Diagram, let P M R, represent the meridian, A Z O the Equator, M Z R the Horizon, H the place of the Sun, A H his distance from the meridian, which (for Example sake) let us here suppose to be, 2 houres, or 30 degrees.



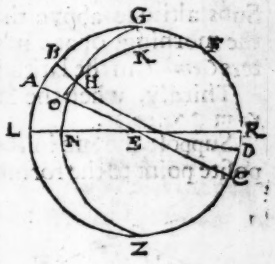
Wherefore in the Triangle P A H we have given (1) A P the distance of the Zenith from the Equator, equall to the Poles Elevation, 52 deg. 30 min. (2) A H the distance of the Sun from the meridian, 30 deg; hence to finde the Suns Altitude L H, I say.

As the Radius 90 deg.	10,00000
To the Cosine of A H 30 deg. 0 min.	9,93753
So the Cosine of A P 52 deg. 30 min.	9,78445
To the Cosine of P H 58 deg. 11 min.	9,72198

Whose Complement L H 31 deg. 49 min. is the Suns Altitude required.

Secondly, when the Sun is in the North Signes ♈ ♉ ♊ ♋ ♌ ♍ In

In the Diagram annexed let G L Z R represent the meridian, A E C the Equinoctiall, F the North Pole of the World, L E R the Horizon, G the Zenith, B H D a parallel of the Suns Declination, F H O the meridian of the Sun, B H B F H the distance of the Sun, from the meridian of the place, O H the Suns Declination North, G F the Complement of the Poles Elevation.



Let it be required to finde the Suns Altitude at 9. of the Clock before noon, when he enters *Gemini*, in the North Latitude of 52 deg. 30 min. wherefore in the triangle F G H we have known, (1) G F the Complement of the Poles Elevation, 37 deg. 30 min, (2) F H the Complement of the Suns Declination, 69 deg. 47 min. (3) the comprehended angle G F H, the distance of the Sun from the meridian 30 deg. hence to finde G H, and consequently the Suns Altitude N H, I say,

(1)

As the Radius 90 deg.	10,00000
To the tangent of F G 37 deg. 30 min.	9,88498
So the Cosine of the angle G F H 30 d. 0 m.	9,93753
To the tangent of F K 33 deg. 36 min.	9,82251

From the Complement of the Suns Declination F H 69 deg 47 min. substract F K 33 deg. 36 min. there remaines K H 36 deg. 11 min.

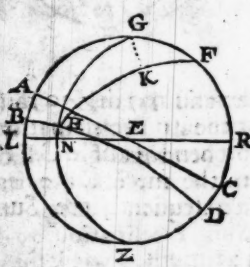
(2)

As the cosine of F K 33 deg. 36 min.	9,92060
To the cosine of G F 37 deg. 30 min:	9,89946
So the cosine of K H 36 deg. 11 min.	9,90694
	19,80640
To the cosine of G H 39 deg. 45 min.	9,88580

Whose complement N H 50 deg: 15 min. is the Suns altitude above the Horizon, at 10 a clock in the morning, or at 2 in the afternoon, when he enters *Gemini*, in the latitude of 52 d: and a half North.

Thirdly, when the Sun is in the Southern Signs, ♎ ♏ ♐ ♑ ♒ ♓.

Suppose the Sun in the winter season be in the opposite point to the former, having Southern declination 29 deg. 13 min. and be also distant from the meridian 30 degrees, therefore in this diagram, we have given, in the obliquangled triangle G F H (1) F G as before, 37 deg. 30 min. (2) F H 110 deg. 13 mi. the sum of the Quadrant added to the Suns declination (3) the angle G F H 30 deg: Hence to find the Suns Altitude N H, I say as before:



(1)

As the radius 90 deg.	10,00000
To the tangent of F G 37 deg. 30 min.	9,88494
So the cosine of the angle G F H 30 d. 0 m:	9,93753
To the tangent of F K 33 d. 36 m: as before	9,82251

From the arch F H 110 deg. 13 min. substract the arch

arch F K 33 d. 36 m. and there rests K H 76 d. 37 m

(2)

As the cosine of F K 33 deg. 36 min.	9,92060
To the cosine of G F 37 deg. 30 min.	9,89946
So the cosine of K H 76 deg. 37 min.	9,36448
	19,26394
To the cosine of G H 77 deg. 16 min.	9,43343

Now the complement of G H is N H 12 d. 44 m. which is the Suns Altitude required.

PROBL. XIV.

The Suns Altitude, his Distance from the Meridian, and Declination being given, to finde his Azimuth.

IN the obliquanguled sphæricall Triangle G F H of the second diagram of the last Probleme, we have known, (1) G H the complement of the Suns altitude 39 deg, 45 min, (2) the angle G F H the distance of the Sun from the meridian 30 deg, (3) F H the complement of the Suns Declination 69 d. 47 m, then to finde the Suns azimuth, I work thus.

As the sine of G H 39 deg, 45 min,	9,80580
To the sine of the angle G F H 30 d, 0 m,	9,69897
To the sine of F H 69 deg, 47 min,	9,97238
	19,67135
To the sine of *F G H* the Suns azimuth 47 deg, 12 min,	9,86555

Probl. XV.

The Poles Elevation, with the Suns Altitude, and Declination given, to finde the Suns Azimuth.

IN the obliquanguled triangle *G H F* of the 13th probleme, second example, the complement of the Suns altitude *G H* is 39 deg, 45 min, the complement of the Suns declination *F H* 69 deg, 47 m, and the complement of the poles elevation, *G F* 37 deg, 30 min, which known, you may frame your operation thus.

Sides	*G H*	39 deg,	45 min	9,80580 } adde
	G F	37	30	9,78445 }
Difference		2	15	19,59025 — 1
Base *F H*		69	47	20,00000 — 2
Sum		72	semi. 36 d, 1′	9,76939 } adde
Differ,		67	semi, 33 46	9,74493 }
				19,51432 — 3
				19,92407 — 4
The correspon, arch 66 d, 24′				9,96203

Whose double 132 deg, 48 min, is the angle *F G H*, now the complement thereof 47 d, 12 min, is the angle *B G H*, which is the Suns azimuth, as before.

Unto these usefull Problems of Astronomy, we shall annex some others of Horologiography, wherein (though it is not our intention in this place to treat of the whole Art of Dialling, *yet) we shall shew*

shew my Surveyor, *how he may describe the most usuall sorts, which are the Horizontall, the Direct North and South, and the East and West planes, together with the erect North and South Planes, declining East and West to any Declination given, according to the projection of the Sphare.*

PROBL. XVI.

To describe the Horizontall Diall.

FIrst we shall begin with the *Horizontall*, which is such a Plane, as is parallel to the *Horizontall* circle of the *Sphære*, whose poles lye directly in the Zenith and Nadir of the place of your habitation.

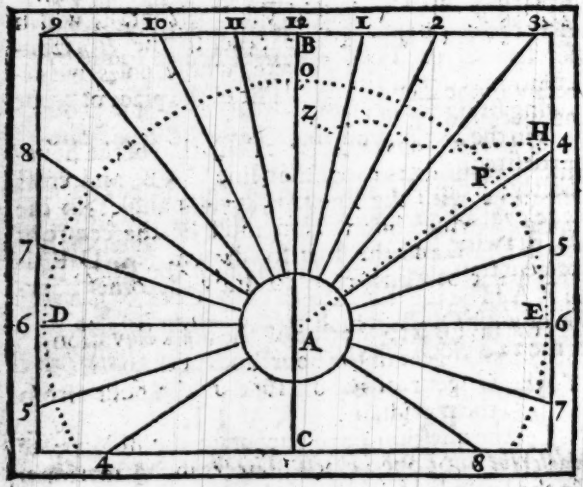
Before we come to the calculation of the hour-distances, draw the meridian line C A B, and cross the same with the line D E, at right angles, in the point A, which intersection must be the centre of your Diall, and the line so drawn, *viz.* D E, is the 6 a clock-line, then to draw the other hour-lines, say,

As the radius is to the sine of the poles elevation;
So is the tangent of the hour-lines at the pole;
To the tangent of the distance of the hour from the meridian.

Let the question be to supputate the distance of the eleven, or one a clock-hour from the meridian in the latitude of 52 deg, and 30 min, therefore according to the former analogie, it may thus be resolved.

Radius 90 deg, 10,00000
Sine of the poles elevation 52 deg, 30 min, 9,89946
Tangent of the equinoctiall distance of 1 hour from the meridian 15 deg, 9,42805
Tangent of the hour from the meri. 12 d, 0′ 9,32751

After this manner may you finde the distance of 2 and 10 of the clock, and of 3 and 9 of the clock, and so of the rest; only you are to remember, that the equinoctiall distance of 1 a clock, is 15 deg. of 2 a clock 30 deg. of 3 a clock 45 deg. of 4 a clock 60 deg. of 5 a clock 75 deg. as in the following table.



The distance of the hour-lines from the meridian being now found, you may project them into the former Scheme thus.

Take

Hours		Equin. distanc.		Hour arches	
12		0	0	0	0
11	1	15	0	12	0
10	2	30	0	24	37
9	3	45	0	38	26
8	4	60	0	53	57
7	5	75	0	71	20
6	6	90	0	90	0

Take with your compaſſes 60 deg. from a line of chords, and with the ſame extent, ſetting one foot in the centre A, with the other deſcribe the circle D O E, which done, take from the ſame ſcale of chords, all the hour diſtances, and placing one foot of your compaſſes in O, (where the circle interſects the meridian) with the other ſet out the hour diſtances before found by calculation, both waies upon the circle D O E, then drawing ſtreight lines from the center A, to thoſe pricks in the circle, you ſhall have the true hour-lines deſired.

Laſtly, from the ſaid line of chords, take the poles elevation 52 deg, 30 min, and ſet it from O to P, drawing the prickt line A P H, which ſhall repreſent the upper edge, or height of the ſtile; ſo will Z A H be the true pattern of the Cock, or Gnomon of your Diall, which erect at right angles over the 12 a clock line, and ſo is your Diall finiſhed.

PROBL. XVII.

To deſcribe the Erect, Direct North or South Diall.

THe making of this differs very little from the horizontall, only there in the calculative part, you took the poles elevation, but here you muſt take

take its complement, and insert only 12 hours, as will appear by the following figure.

Let the question again be to calculate the distance of eleven, or one a clock from the meridian; in the said latitude of 52 deg, 30 min.

The Calculation.

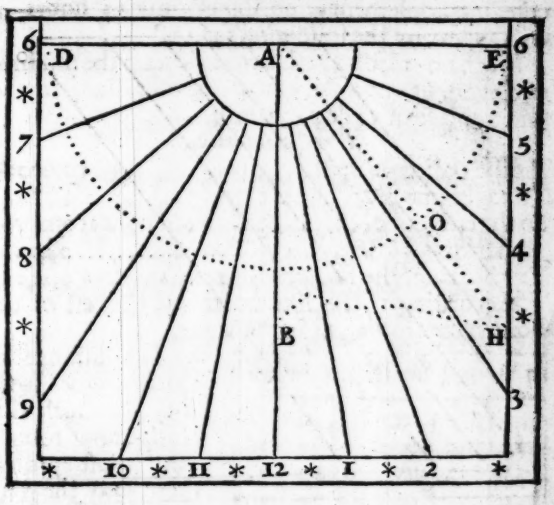
As the radius 90 deg. 10,00000
To the cosine of the poles eleva. 52 d. 30′ 9,78445
So the tangent of the distance of one hour from the meridian 15 deg. 9,42805
To the tan. of the ho. arch from 12, *vi.* 9d. 16′ 9,21250

According to the like order are the rest of the hour arches found, as in the Table.

Hour		Eq. Dist.		Ho. ar	
12		0	0	0	0
11	1	15	0	9	16
10	2	30	0	19	22
9	3	45	0	31	20
8	4	60	0	46	31
7	5	75	0	66	15
6	6	90	0	90	0

The distance of the hour lines from the 12 a clock line being now found, you must project them into the diall after the same manner, as we shewed in the horizontall, only for the height of the stile, you are to take the complement of the poles elevation, 37 deg, 30 min, and then work as before, as you may see by this diagram.

PROBL;

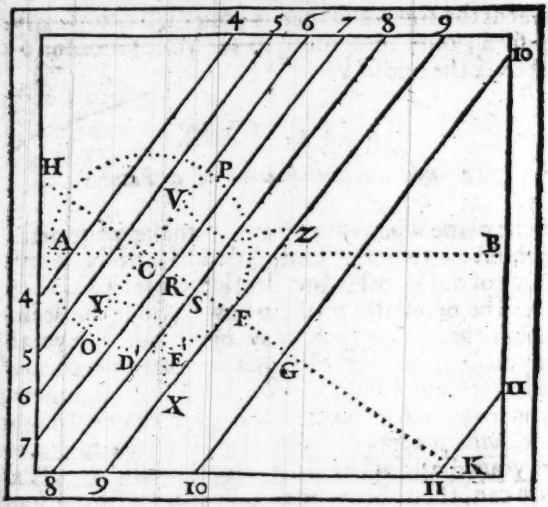


PROBL. XVIII.

To describe the direct East or West Diall.

FIrst draw the horizontall line of the plane A B, and this diall may most exactly be projected by a line of Naturall Tangents, but we shall here give you that way which is more easie, and fitting all capacities.

Let the substilar line (which stands in the line of six) make an angle therewith, equall to the latitude of the place, as 6. C B, so that it may point exactly to the pole of the World; then from the point C, draw the line H C K, at right angles to the 6 a clock line. Next upon C, as a center, describe a circle



circle, whoſe radius ſhall be equall to the height of the ſtile G F, which prick off from O to E, from F to D, from B to G, and from G twice to K. Laſtly lay a ruler from P to D, and it will interſect the line H K in the point R, where make a prick for the 7 a clock line. Again, lay the ruler from P to E, and you ſhall find it to cut the line *H K* in S for the 8 a clock line. The 9 a clock line is at the point F, the 10 a clock line at the point G, and the 11 a clock line at the point K; then from every of the ſaid points draw lines parallel to the ſubſtile, or hour line of 6, and you ſhall have ſix of the hour lines inſerted. Laſtly, make the hour lines of 5 and 4 in the morning, as far diſtant from the ſubſtile towards the left hand, as the lines of 7 and 8 are towards

towards the right, and then is your diall compleatly finished; only remember to set your Gnomon erect over the line O P.

PROBL. XIX.

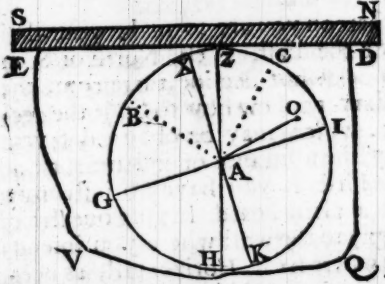
To finde the Declination of a Plane.

IF the plane whereon you are to make your diall, behold neither the East, West, North or South points of the World, but decline therefrom, then it will be necessary to shew how to finde the declination thereof, which may be obtained severall wayes, both by the assistance of instruments, and other wayes. First, if you have no instrument, you may take a plain board, having one streight side, which apply to the wall where you intend to set your diall, where fix it *Horizontall*, as neer as you can, then about the middle thereof set one foot of your compasses, and describe a circle, in the centre whereof erect a wyer of a convenient length, which done, observe in the forenoon, when the end of the shadow thereof toucheth the said circle, and there make a prick; and in the afternoon, when the shadow of the top of the wyer returneth to the same circle again, make another prick therein, then with your compasses measure the middle between these two pricks, and there make a mark, then from the wyer, or centre, to that mark, draw a streight line, which shall represent the meridian. Next from the wyer extend another line through the circumference of the said circle, to make right angles upon the plane, or streight edge of your board, which line may be called the axis or pole of the plane. Lastly, the distance of these two pricks

in

in the circumference of the circle, is the true declination of the plane, which you may know at first sight, whether it be North or South, by ocular inspection only.

Example, let S N D E represent the face of the plain, whereon I am to make my diall, to which I apply the streight edge of the board D E, as in this Figure. Then about the middle of the board DEVQ, *viz*, at A, I set one foot of my compasses, and with the other (opened to 60 deg. upon my line of chords) I describe the circle *Z B H C*, in the centre whereof A, I erect a wyer, as A O, which done, I finde by observation, that the shadow of the top of the wyer, toucheth the circle in the forenoon, at the point B, where I make a little mark. Likewise I observe in the afternoon, that it toucheth the said circle in the point C, then I measure their distance with my compasses, and set the half thereof from B, or C to X, and drawing a line with my ruler from A to X, we shall have the meridian line K A X exactly described.



Lastly, opening my compasses, I take the distance Z X, which I apply to my scale of chords, and find the arch thereof 18 deg. 10 min. and so much is the declination of the plane E D N S, which you may see by the meridian line K X, is towards the West.

West. This then is a South plane declining West, 18 deg. 10 min.

Although this way of finding the declination of a plane, is most easie, yet because it requires observation both in the forenoon and afternoon, so that it cannot be effected without some considerable time, I shall now shew you another way or two, how to performe the same at one observation.

Otherwise.

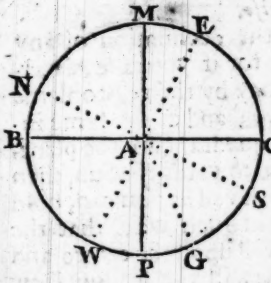
Again, you may finde the declination of any plane by the *Suns Azimuth*, for if you take his altitude by a quadrant, you may by the 15 Probleme hereof, calculate his *Azimuth*; and at the same instant, apply one edge of the quadrant to the plane, that the limb thereof may be towards the Sun, then placing the quadrant as neer levell as you can, hold up a thred and a plummet, in such wise, that the shadow of the thrid may fall upon the centre and limb of the quadrant, then will the shadow shew upon the limb how many degrees the Sun is distant from that side of the quadrant which represents the axis, or pole of the plain, which may be called the distance of the Sun from the pole of the plain.

Again, at the same instant observe the Suns altitude by your quadrant, by which you may get his azimuth from the South point, as is said before. Then to finde the declination, observe the two following rules.

1 If the shadow fall between the South, and the perpendicular side of the quadrant, that represents the axis of the plane, then adde the distance of the Sun from the pole of the plane, and his azimuth together, the sum is the declination of the plane, which is upon the same coast the azimuth is, as for Example.

Let

Let us suppose the *Horizontall* distance of the Sun from the pole of the plain be 20 deg. and the Suns azimuth from the South be 42 deg. therefore from hence to finde the declination, I describe the circle B P C M, whereupon I draw the diameter B A C, representing the *Horizontall* line of the plane, and crosse it at right angles in the centre A, with the diameter M A P, which represents the pole of the plane. Then with my compasses, I take from the *Scale* of *Chords*, the *Horizontall distance*, or distance of the *Sun* from the pole of the plane 20 deg. and set it from P to G, and then from G to S, set off the Suns azimuth 42 deg.



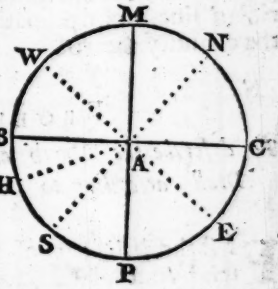
which done, draw the diameter *S N*, and crosse it at right angles with the diameter E A W, so will *S* represent the South, N the North, E the East, and W the West. Now forasmuch as the line of the shadow of the thred G A, falleth between P the pole of the plain, and S the South point; therefore according to the former rule, I adde P G the Suns distance from the pole of the plane 20 deg. to G S the Suns azimuth 42 deg. and the sum P S 62 deg. is the declination required, which is towards the West, as the Figure it self sheweth.

2. If the shadow fall not between the South and the axis of the plane, then the difference of the distance and Azimuth is the declination of the plane, and if the azimuth be the greater of the two, the plane declines to the same coast whereon the Azi-

muth

muth is, but if it be the leſſer, then the plane declineth to the contrary coaſt to that whereon the azimuth is, as you may ſee by this example.

Admit the Suns diſtance from the pole of the plane be taken in the afternoon 70 deg. and the Suns azimuth from the South be then given 44 deg. therefore as before, I draw the circle *M C P B*, and from P to *H*, I ſet off the Suns diſtance from the pole of the plane 70 deg. and from H to S the Suns azimuth 44 deg. now becauſe the South point doth fall between P the pole of the plane, and *H* the diſtance of the Sun from the pole of the plane, therefore (accoreing to the rule) I ſubſtract the *S*uns azimuth *H S* 44 deg. from *H P* the diſtance of the Sun from the pole of the plane, and there remaineth *S P* 26 deg. the declination deſired, which is towards the Eaſt, as you may perceive by the Figure. So that this is a *S*outh plane declining Eaſt 26 degrees.



A third way.

Although the two former wayes are exact, if they are but warily performed, yet inregard they cannot be effected without the help of the *S*un, I ſhall therefore ſhew how you may ſpeedily finde the declination of any plane by the Needle, whether the Sun be clear or not.

Apply the North ſide of the inſtrument, wherein the Needle is placed unto the wall, and hold it Horizontally, as near as you can, that the Needle may have

have free liberty to play too and fro, and when it ſtands, obſerve upon the limb of the chard, over which it moves, upon what degree the Needle ſtands, for that is the declination reckoned from the South. And if you would know the coaſt, obſerve that if the Needle ſtand upon the Eaſt ſide the meridian line, then is the declination of the plane Weſt, but if it ſtand on the weſt ſide the meridian line, the declination is Eaſt, according to the quantity thereof.

PROBL. XX.

To deſcribe the North and South erect Declining Diall, according to its Declination Eaſt or Weſt.

FIrſt the *declination* of the *plane* whereon you intend your Diall, is to be ſought, as was ſhewed in the laſt *Probleme*, which being attained, we ſhall come to the declination of the *Diall* it ſelf.

Let us ſuppoſe the elevation of the Pole to be 52 deg. 40 min. and the declination of the plane whereon I am to make my *Diall*, be 24 deg. towards the Weſt (ſuch was one of the *Dialls* I lately made for the Right Worſhipfull Sr. *Eraſmus De La Fountain*, at *Kerby-Bellers* in the County of *Leiceſter*) therefore, becauſe the declination is Weſt, the ſtile muſt ſtand on the Eaſt ſide the meridian, or hour line of 12, (but if the declination had been Eaſt, it ſhould have ſtood on the Weſt ſide thereof.) But before we can come to the calculation of the hour diſtances there are three things to be known (1) the Elevation of the pole above the plain, commonly called the height of the ſtile, (2) the diſtance of the ſubſtile from

from the meridian (3) the inclination of the meridian of the plane to the meridian of the place.

The Calculation.

(1)

As the Radius 90 d:	10,00000
To the cosine of the elevation 52 d. 40′	9,78279
So the cosine of the declination 24 d. 0′	9,96073
To the height of the stile 33 d. 38′	9,74352

(2)

As the radius 90 d.	10,00000
To the sine of the Declination 24 d.	9,60931
So the cotangent of the elevation 52 d. 4′	9,88236
To the tangent of the stubstiles distance from the meridian 17 d. 14′	9,49167

(3)

As the radius 90 d.	10,00000
To the sine of the poles elevation 52 d. 30′	9,90043
So the cotangent of the declination 24 d. 0′	10,35142
To the cotangent of the inclination of the meridian 29 d. 15′	10,25185

These things thus found, we shall next proceed to the calculation of the hour-distances: but first we are to consider that the angle between the meridians was found to be 29 deg. 15 min. and because the hour of one is distant from the meridian 15 d. and the hour of two 30 deg. therefore I conclude the subStile will fall between 1 a clock and 2: and if I substract 15 deg. from 29 deg. 15 min. the remainder will be 14 deg. 15 min. the distance of the 1 a Clock-line from the substile.

Again, The distance of 2 of the Clock from the meridian is 30 deg. from which if I substract 29 deg. 15 min. the distance of the 2 of the Clock from the substile will be 0 deg. 45 min. These things being now known, the rest of the houres are

found by a continual addition of 15 deg. for every hour, (and for every half hour 7 deg. 30 min, &c.) as by the following Table you may perceive. Lastly, to finde the distance of each hour-line from the substile, we shall give an example for one of the clock, whose equinoctiall distance from the substile is (as in the following Table) 14 d. and 15 m.

The Calculation.

As the Radius 90 deg. 10,00000
To the sine of the height of the stile 33 d. 38′ 9,74341
So the tangent of the distance of 1 hour, from the substile 14 d. 15 min. 9,40478
To the tangent of the Hour-arch from the substile 8 d. 0′ 9,14819

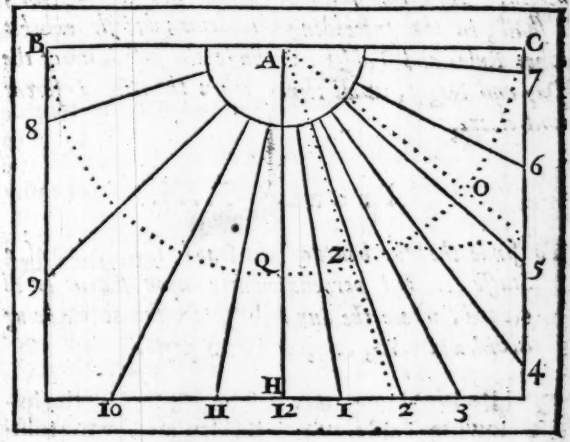
After the same manner we have calculated the following Table, by which the Dial is most easily projected, as we shall here-under shew.

Hour	*Equ.*	*Dist.*	*Ho. Arch.*	
8	89	15	88	39
9	74	15	63	1
10	59	15	42	57
11	44	15	28	21
12	29	15	17	14
1	14	15	8	0
	Merid.		*Substile*	
2	0	45	0	25
3	15	45	8	53
4	30	45	18	14
5	45	45	29	37
6	60	45	44	41
7	75	45	65	22

First draw the horizontal-line *B C* (as in the following Figure) and from the most convenient place thereof, as *A*; let fall the perpendicular *A H*, which shall represent the meridian line of the Plane. Then take 60 deg. from a line of Chords, and making a the center, draw the semicircle *B Z C*. In this circle from *Q* to *Z* prick down the distance of the substile from the meridian which

which was found before 17 deg. 14 min. and from the ſubſtile *Z*, in the ſame circle, I ſet off the height of the ſtile to *O*, 33 deg. 28 min. ſo ſhall Z A O repreſent the *Cock* of the *Diall*. Then from the ſame ſcale of chords, take off with your compaſſes, the

An Erect Diall, Declining from the South Weſtward 24 degrees.



ſeveral hour-diſtances, as they are ready calculated in the Table, *viz.* : 8 deg. 0 min. for one a Clock ; 17 deg. 14 min. for 12 a Clock ; 28 deg. 21 minutes for eleven a Clock, and ſo of the reſt, and prick them down from the ſubſtile, in the circle B Q C, by help of your line of *Chords*. Laſtly, draw ſtreight lines from the center A, to thoſe ſeveral points, and you ſhall have the true hour-lines, which was deſired.

It is not (I suppose) expected, that I should here treat of the whole Art of Dialling, *neither was it my intent so to do, but onely to shew the making of those that are most usefull; whereby my Surveyor (as often as he shall have occasion to make use hereof) may not be destitute of a due and perfect knowledge herein. And now for his further use and delight, I shall, in the succeeding Problems, briefly exhibit other Rules and Tables, to finde the just hour of the Day and Night, at all times, when the Aire is serene and cleere.*

PROBL. XXI.

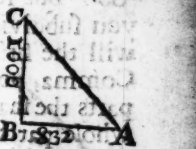
To finde the true houre of the Day by the shadow of a Staffe erected perpendicularly upon plaine levell ground, where the Sun doth shine, the Staffe being divided into 10, 100, *or* 1000 *parts.*

THis Probleme may best be effected by the following Table, which is calculated by the solution of a plain Rectangle Triangle, according to the first Problem of the second Book; for we have given (1) the length of the staffe A C 1000. (2) the angle of the Suns altitude B A C, to finde the length of the shadow A B.

Admit the Sun be in the first point of *Gemini*, and at two a Clock in the afternoon, it is required to finde the length of the shadow of the staffe. By the thirteenth Problem of this Book, the Suns alti-

tude

tude at the same time, is found 15 deg. 15 min. represented by the Angle B A C, which known, with the length of the staffe B C, 1000 to find B A, I say,



As the Radius 90 deg.	10,00000
To the cotang. of the angle BAC 50 d: 15′	9,91996
So the length of the staffe BC 1000,	3,00000
To the length of the shadow BA 832	2,91996

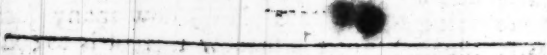
According to this Doctrine was the following *Table* composed, which I shall here explain.

First, The *Staffe*, or *Gnomon* (of what length you please) is here supposed to be divided into 1000 equal parts, and being set upright, the *Table* will shew (according to the Suns place) how many such parts, the length of the shadow thereof is to contain, at any hour of the Day.

Secondly, If the *Staffe* be divided into 100 parts, the former figures, towards the left hand, shew the length of the shadow, and the last figure, remaining towards the right hand, will tell you how much the shadow is above so many even parts, every 100 part being divided into 10.

Thirdly, But if the *Staffe* be divided but into 10 equal parts, then the former figure, or figures, towards the left hand, shews how many of those parts the shadow of the *Staffe* will yield at each hour; and the two last figures, towards the right hand, being distinguished from the former by a Comma, or small prick, will shew how much the shadow is above so many even parts, according to the partition of every of those 10 even parts into

100: But if upon your *Staffe* of 10 equal parts, you ſubdivide each part but into 10 more; then will the firſt figure of the fraction, next after the Comma, point out how many of theſe ſubdivided parts the ſhadow ſhall contain, over and above the whole parts towards the left hand. But to illuſtrate and make this more cleere, I ſhall add Examples next after the Table.



A Table

A Table shewing the true Houre of the Day, by a plain staff, divided into 10, 100, or 1000, equal parts.

Ho.	Before no. / After no.	12	11 / 1	10 / 2	9 / 3	8 / 4	7 / 5	6 / 6	5 / 7
♋	0 0	5 54	6 05	7 50	9 88	13 49	19 25	29 97	157 20
	25 5	5 57	6 08	7 54	9 92	13 54	19 34	30 19	157 99
	20 10	5 62	6 13	7 59	9 98	13 65	19 47	30 47	159 02
	15 15	5 75	6 25	7 70	10 12	13 83	19 82	31 24	161 85
	10 20	5 88	6 39	7 86	10 30	14 08	20 20	32 07	165 22
	5 25	6 09	6 60	8 08	10 56	14 41	20 81	33 47	171 15
♌	0 0	6 32	6 83	8 32	10 84	14 81	21 48	35 07	178 61
	25 5	6 61	7 12	8 63	11 21	15 32	22 40	37 34	190 58
	20 10	6 92	7 44	8 97	11 61	15 91	23 42	40 01	107 79
	15 15	7 30	7 82	9 38	12 12	16 63	24 76	43 63	138 38
	10 20	7 71	8 23	9 83	12 67	17 43	26 26	48 08	196 27
	5 25	8 18	8 72	10 36	13 33	18 40	28 16	54 31	338 00
♎	0 0	8 69	9 23	10 93	14 04	19 48	30 35	62 32	864 00
	25 5	9 27	9 83	11 59	14 88	20 78	33 16	74 29	
	20 10	9 88	10 46	12 31	15 80	22 25	36 47	92 18	
	15 15	10 57	11 18	13 12	16 87	24 00	40 74	121 85	
	10 20	11 32	11 96	14 02	18 06	26 05	46 06	181 71	
	5 25	12 14	12 82	15 01	19 43	28 45	53 13	363 69	
♈	0 0	13 03	13 75	16 12	20 98	31 30	62 67		
	25 5	14 01	14 78	17 35	22 73	34 72	76 30		
	20 10	15 09	15 92	18 73	24 75	38 95	97 32		
	15 15	16 26	17 18	20 26	27 08	44 11	133 00		
	10 20	17 57	18 56	21 99	29 80	50 81	209 46		
	5 25	18 95	20 06	23 88	32 90	59 23			
♓	0 0	20 52	21 74	26 07	36 64	70 85			
	25 5	22 15	23 52	28 40	40 81	86 21			
	20 10	23 96	25 52	31 11	45 99	109 88			
	15 15	25 84	27 57	33 9[illegible]	51 78	145 13			
	10 20	27 95	29 89	37 12	58 91	208 15			
	5 25	30 05	32 14	40 50	66 78	331 68			
♒	0 0	32 10	34 61	44 04	76 00	828 43			
	25 5	34 08	36 81	47 62	86 32				
	20 10	36 00	39 14	51 09	97 18				
	15 15	37 63	40 87	54 18	107 97				
	10 20	39 09	42 52	56 58	117 25				
	5 25	39 71	43 26	58 25	123 84				
♑	0 0	40 11	43 72	59 00	126 36				

The Use of the former Table.

SEek the place of the Sun in the first or second Columne, towards the left hand; and having divided your staffe into equall parts (as before was taught) set it upright in some plain level place, where the Sun doth shine, and then measure with your staffe, how many parts the shadow thereof contains, which finde out in the Table right against the Suns place, and in the same Columne overhead, you have the hour of the day.

An Example where the Staffe is divided into 1000, *equall Parts.*

Suppose that upon the tenth day of *March*, when the Sun enters *Aries*, I erect my staffe upon plain levell ground, and finde the shadow thereof to contain 3130 parts, (that is, three times the length of my staffe, and 130 parts more:) therefore seeking in the Table for the number of the said parts, against 0 deg. of ♈ *Aries*, I finde the same in the seventh Columne of the Table, under the houres of 8, and 4; so that if the observation had been in the forenoon, it had been 8 a Clock; but if in the afternoon, 4 a Clock.

An Example where the Staffe is divided into 100 *equall parts.*

But if your staffe be divided but into 100 parts, and you finde the shadow thereof to be 313 of the same parts in length, seek out the same in the Table (leaving out the last figure towards the right hand)

hand) and it giveth the hour of the day, as before.

An Example where the Staff is divided into 10 *equall parts.*

Laſtly, If your ſtaffe be divided but into 10 equal parts, then the former figures diſtinguiſhed from the other two, towards the right hand, ſhew the length of the ſhadow, at the ſame time, to be 31 whole parts, and 30 parts of 100, or 3 parts of 10, that is, three times the length of my ſtaffe, and one whole part, and ſomething above a quarter of a part more.

And if according to this Example, the ſame day I ſhould ſet up my ſtaffe, and find the ſhadow thereof to contain 62 whole parts, and 67, which is about $\frac{2}{3}$ of a part, the Table will ſhew me that tis then 7 a clock, if the obſervation be in the forenoon, or 5 if it be in the afternoon.

Thoſe that ſtand upon curioſites may uſe the firſt example; but otherwiſe, for finding the hour of the day, without ſenſible error, you may leave out the two laſt figures towards the right hand, if your ſtaff be divided but into ten parts.

But I need not ſpeake any further, to explaine this matter, ſeeing the Table of it ſelf is ſo eaſie, that what is already ſaid, may ſuffice. And now having ſhewed my Surveyor, how he may find the juſt hour of the Day, at all times, by help of the Sun, I ſhall here alſo ſhew him, how to finde the true houre of the Night by the Moon, and Stars, when they are ſeen.

PROBL.

PROBL. XXII.

To finde the just Houre of the Night, by the shadow of the Moon, on a Sun Diall.

THis Probleme cannot be performed, without the true places of the Sun and Moon be first known, that & therfore, you may do it exactly the most certaine way will be, to have recourse to my Ephemerides, where having found their places, and Right Ascensions, you are to substract the Right Assention of the Sun, from the right Ascension of the Moon, (as I have there directed) and the Remainer will be the time of the Moons culmination, or coming to the South: Or if you turn to my Almanack, you have her southing ready set down, against the day desired, without further trouble. Then repaire to a *Sun Diall*, and note the Houre, as you doe by the Sun, and see what the shadow wants, or is past the 12 a clock-line, for so much it wants, or is past the Houre, and min. of the time of her coming to the South, as you may perceive by this following Example:

On the sixth of *August* this present year, I found by my *Almanack*, the time of the Moons coming to the South to be at 10 a clock and 27 min. in the evening; and the same night, as I was looking on a *Sun-Diall*, (being then in *Leicester*) I found the shadow fall exactly on the hour of 10; that is 2 hours short of the 12 a clock-line: therefore from 10 hours 27 min. I take 2 hours, and there remains 8 a clock and 27 min. for the true hour of the night. But if the same night the shadow had been 2 hours past the 12 a clock line, then it had been 2 hours

past

paſt the time of her coming to the South 10 hours 27 min. and therefore 12 a clock and 27 min. After the ſame manner may you finde the hour of the night at all times, when the Moon doth ſhine.

PROBL. XXIII.

To finde the true Hour of the Night by the fixed Stars.

ALthough in the former *Probleme* you are taught how to finde the juſt hour of the night by the ſhadow of the Moon, on a *Sun-Diall*, which is of excellent uſe, yet in regard ſhe is not alwayes to be ſeen, I ſhall here ſhew you alſo how to effect the ſame by the *Stars*, for which purpoſe I have compoſed the two following Tables; the firſt whereof ſhews the right aſcenſion and ſemidiurnall-Arch of 80 of the principalleſt fixed Stars: and the ſecond ſhews the Suns right aſcenſion every other day, from the year 1660, to the year 1680.

A Table

A Table shewing, the Right Ascension, and Semidiurnall Arches, of 80 of the principallest of the fixed Stars, which (without Sensible errour) will serve from the year 1460. to the year 1680.

Names of the Stars.	Right Asc. Ho.	Min.	Semi Arch Ho.	Min.
Schedir in Cassiopeia	0	22	Set	not
Southern Star of the Whales-taile	0	27	4	4
The Star in the Hexion of Cassiopeia	0	37	Set	not
The Girdle of Andromeda	0	51	10	6
The Knee of Cassiopeia	1	5	Set	not
The Brighter Star in the North knot of ♓	1	14	4	45
The former Horne of the Ram. ♈	1	36	7	39
Whales Belly	1	36	4	56
Hinder Horne of the Ram	1	37	7	49
South foot of Andromeda	1	43	Set	not
Bright Star in the Head of the Ram	1	49	8	7
The middle Star in the Rams taile	1	56	7	53
Bright Star in the jaw of the Whale	2	45	5	45
The Head of Medusa. Algol	2	47	Set	not
The Bright side of Persens	2	51	Set	not
The middlemost of the 7 Stars Pleiades	3	28	8	16
North Eye of the Bull	4	9	7	44
South Eye. Aldebaran	4	17	7	27
In the root of the South horn	4	32	7	43
The Goat	4	52	Set	not
Bright foot of Orion. Regel	4	59	5	14
North Horn of the Bull	5	6	9	0
The former shoulder of Orion	5	8	6	32
Former Star of Orions Belt	5	16	5	57
The Highest Star of Orions Head	5	17	8	1
Southern horn of the Bull	5	18	8	1
Middlemost Star of Orions Belt	5	20	5	52
The Lower Star of the Belt	5	24	5	49
Right Shoulder of Auriga	5	36	Set	not
Following shoulder of Orion	5	38	6	39
Former Star in the right hand of Orion	5	49	7	21
The bright foot of ♊	6	19	7	32
Syrius. The greater Dogge	6	31	4	30
The * in the Belly of the great Dogge	6	55	3	21
The * in the forhead towards the right ear	7	7	4	52

Procyon. The lesser Dogge	7	22	6	32
The lower Head of ♊	7	26	9	4
Bright in the hinder deck of the ship.*	7	54	3	42
North Asellus	8	23	8	14
South Asellus	8	25	7	50
The Head of Hydra.	9	12	6.	38
Lyons heart Regulus	9	50	7	14
Star in the hinder part of Lyons neck	9	58	8	32
The Lyons tail	11	32	7	32
The Virgins Girdle	12	39	6	28
Vindemiatrix	12	46	7	9
The Virgins Spick	13	8	5	11
Arcturus	14	1	8	2
Left shoulder of Bootes	14	19	*Set*	*not*
South Ballance	14	33	4	40
North Ballance	15	0	5	17
Bright Star of the Crown	15	25	8	57
Bright Star of the Serpents neck	15	29	6	40
Antares. The Scorpions heart	16	9	3	23
Right shoulder of Hercules	16	16	8	10
Left Knee of Ophinchus	16	19	5	8
Right Knee of Ophinchus	16	46	4	36
Head of Hercules	16	59	7	22
Head of Ophinchus	17	20	7	10
Bright Star of the Dragons Head	17	50	*Set*	*not*
Bright Star of the Harp	18	22	*Set*	*not*
The Taile of the Vulture	18	51	7	14
The Swans Bill	19	18	8	51
Bright Star of the Vulture	19	35	6	43
Higher Wing of the Swan	19	35	*Set*	*not*
Higher Horn of the Goat	20	0	4	46
Lower Horn of the Goat	20	3	4	33
The Swans breast	20	11	*Set*	*not*
Left hand of the Waterbearer	20	29	5	3
The Swans taile	20	31	*Set*	*not*
Lower Wing of the Swan	20	33	9	48
Left shoulder of the Waterbearer	21	13	5	23
Girale of the Cepheus	21	25	*Set*	*not*
The mouth of Pegasus	21	28	6	44
Right shoulder of the Waterbearer	21	47	5	50
Fomahant ♒	22	39	2	28
Scheat	22	48	8	42
Marchab	22	49.	7	13
The head of Andromeda	23	52	8	51
Bright Star in the Chair of Cassiopeia	23	53	*Set*	*not*

A Table of the Suns Right Ascension in Ho. and min. for every other day, in the following years.

Days.	January. 1660 1664 1668 1672 1676	1661 1665 1669 1673 1677	1662 1666 1670 1674 1678	1663 1667 1671 1675 1679	February 1660 1664 1668 1672 1676	1661 1665 1669 1673 1677	1662 1666 1670 1674 1678	1663 1667 1671 1675 1679
1	19 31	19 35	19 34	19 33	21 40	21 43	21 42	21 41
3	19 40	19 44	19 43	19 42	21 48	21 51	21 50	21 49
5	19 49	19 52	19 51	19 50	21 56	21 59	21 58	21 57
7	19 57	20 0	19 59	19 59	22 3	22 6	22 5	22 4
9	20 6	20 9	20 8	20 7	22 11	22 14	22 13	22 12
11	20 14	20 18	20 16	20 16	22 19	22 21	22 21	22 19
13	20 23	20 26	20 25	20 24	22 27	22 29	22 28	22 27
15	20 31	20 34	20 33	20 32	22 34	22 36	22 36	22 35
17	20 39	20 42	20 42	20 41	22 41	22 44	22 43	22 42
19	20 48	20 51	20 50	20 49	22 49	22 51	22 51	22 50
21	20 56	20 59	20 58	20 57	22 56	22 59	22 58	22 57
23	21 4	21 7	21 6	21 5	23 3	23 6	23 6	23 5
25	21 12	21 15	21 14	21 13	23 11	23 14	23 13	23 12
27	21 20	21 23	21 22	21 21	23 19	23 22	23 22	23 21
29	21 28	21 31	21 30	21 29	23 26			

	March.				April.			
1	23 30	23 29	23 28	23 27	1 23	1 22	1 21	1 20
3	23 37	23 36	23 34	23 34	1 32	1 29	1 28	1 27
5	23 44	23 44	23 43	23 42	1 38	1 36	1 35	1 34
7	23 51	23 51	23 50	23 49	1 45	1 44	1 43	1 42
9	23 59	23 58	23 57	23 56	1 52	1 51	1 50	1 49
11	0 6	0 5	0 4	0 3	2 0	1 59	1 58	1 57
13	0 14	0 13	0 12	0 11	2 7	2 6	2 5	2 4
15	0 21	0 20	0 19	0 18	2 14	2 13	2 12	2 12
17	0 28	0 27	0 26	0 25	2 22	2 21	2 20	2 19
19	0 35	0 35	0 34	0 32	2 29	2 28	2 28	2 27
21	0 42	0 42	0 41	0 40	2 37	2 39	2 36	2 34
23	0 50	0 49	0 48	0 47	2 45	2 44	2 43	2 42
25	0 57	0 56	0 55	0 54	2 53	2 52	2 51	2 50
27	1 4	1 3	1 2	1 1	3 0	3 0	2 58	2 57
29	1 12	1 11	1 10	1 9	3 8	3 7	3 6	3 5

A Table of the Suns Right Ascension in Ho. and min. for every other day in the following years.

Dayes.	May 1660, 1664, 1668, 1672, 1676	May 1661, 1665, 1669, 1673, 1677	May 1662, 1666, 1670, 1674, 1678	May 1663, 1667, 1671, 1675, 1679	June 1660, 1664, 1668, 1672, 1676	June 1661, 1665, 1669, 1673, 1677	June 1662, 1666, 1670, 1674, 1678	June 1663, 1667, 1671, 1675, 1679
1	3 16	3 15	3 14	3 13	5 21	5 20	5 19	5 18
3	3 24	3 23	3 22	3 21	5 29	5 28	5 27	5 26
5	3 32	3 30	3 30	3 29	5 38	5 36	5 35	5 34
7	3 40	3 39	3 38	3 37	5 46	5 44	5 44	5 43
9	3 47	3 47	3 46	3 45	5 54	5 53	5 52	5 51
11	3 56	3 55	3 54	3 53	6 2	6 1	6 0	5 59
13	4 4	4 2	4 2	4 1	6 11	6 10	6 9	6 7
15	4 12	4 10	4 9	4 9	6 19	6 18	6 17	6 16
17	4 19	4 18	4 17	4 16	6 28	6 26	6 25	6 24
19	4 28	4 27	4 25	4 25	6 36	6 35	6 34	6 32
21	4 36	4 35	4 34	4 33	6 44	6 43	6 42	6 41
23	4 44	4 43	4 42	4 41	6 52	6 51	6 50	6 49
25	4 52	4 51	4 50	4 49	7 0	6 59	6 58	6 57
27	5 1	4 59	4 58	4 57	7 9	7 8	7 7	7 6
29	5 9	5 8	5 7	5 5	7 17	7 16	7 15	7 14

Dayes.	July 1660, 1664, 1668, 1672, 1676	July 1661, 1665, 1669, 1673, 1677	July 1662, 1666, 1670, 1674, 1678	July 1663, 1667, 1671, 1675, 1679	Auguſt 1660, 1664, 1668, 1672, 1676	Auguſt 1661, 1665, 1669, 1673, 1677	Auguſt 1662, 1666, 1670, 1674, 1678	Auguſt 1663, 1667, 1671, 1675, 1679
1	7 25	7 24	7 23	7 22	9 27	9 26	9 25	9 24
3	7 33	7 32	7 31	7 30	9 34	9 33	9 32	9 31
5	7 41	7 40	7 39	7 38	9 42	9 41	9 40	9 39
7	7 49	7 48	7 47	7 46	9 49	9 48	9 47	9 46
9	7 57	7 56	7 55	7 54	9 57	9 56	9 55	9 54
11	8 5	8 4	8 3	8 2	10 4	10 3	10 2	10 1
13	8 13	8 12	8 11	8 10	10 11	10 10	10 9	10 9
15	8 21	8 20	8 19	8 18	10 19	10 18	1017	1016
17	8 29	8 28	8 27	8 26	10 26	10 25	1024	1023
19	8 37	8 36	8 35	8 34	10 33	10 32	1031	1031
21	8 45	8 44	8 43	8 42	10 40	10 39	1039	1038
23	8 52	8 51	8 50	8 49	10 47	10 47	1046	1045
25	9 0	8 59	8 58	8 57	10 55	10 54	1053	1052
27	9 7	9 7	9 6	9 4	11 2	11 1	11 1	11 0
29	9 15	9 14	9 13	9 12	11 10	11 8	11 8	11 7

A Table of the Suns Right Ascension in Ho. and min. for every other day, in the following years.

Days.	September. 1660 / 1664 / 1668 / 1672 / 1676	1661 / 1665 / 1669 / 1673 / 1677	1662 / 1666 / 1670 / 1674 / 1678	1663 / 1667 / 1671 / 1675 / 1679	October. 1660 / 1664 / 1668 / 1672 / 1676	1661 / 1665 / 1669 / 1673 / 1677	1662 / 1666 / 1670 / 1674 / 1678	1663 / 1667 / 1671 / 1675 / 1679
1	11 20	11 19	11 18	11 18	13 9	13 8	13 7	13 6
3	11 28	11 27	11 26	11 25	13 16	13 15	13 14	13 13
5	11 35	11 34	11 33	11 32	13 24	13 23	13 22	13 21
7	11 42	11 41	11 40	11 39	13 31	13 30	13 29	13 28
9	11 49	11 48	11 47	11 46	13 39	13 38	13 37	13 36
11	11 56	11 55	11 54	11 54	13 47	13 46	13 45	13 44
13	12 4	12 3	12 2	12 1	13 54	13 53	13 52	13 51
15	12 11	12 10	12 9	12 8	14 2	14 1	14 0	13 59
17	12 18	12 17	12 16	12 15	14 10	14 9	14 8	14 7
19	12 25	12 24	12 24	12 23	14 18	14 17	14 16	14 15
21	12 33	12 32	12 31	12 30	14 25	14 24	14 23	14 22
23	12 40	12 39	12 38	12 37	14 33	14 32	14 31	14 30
25	12 47	12 46	12 45	12 44	14 41	14 40	14 39	14 38
27	12 54	12 53	12 52	12 51	14 49	14 48	14 47	14 46
29	13 2	13 1	13 0	12 59	14 57	14 56	14 55	14 54

	November.				December.			
1	15 9	15 8	15 7	15 6	17 18	17 16	17 15	17 14
3	15 18	15 17	15 16	15 15	17 26	17 25	17 24	17 23
5	15 26	15 25	15 24	15 23	17 35	17 34	17 33	17 32
7	15 34	15 33	15 32	15 31	17 44	17 43	17 42	17 41
9	15 42	15 41	15 40	15 39	17 53	17 52	17 51	17 50
11	15 51	15 50	15 49	15 48	18 2	18 1	18 0	17 59
13	15 59	15 58	15 57	15 56	18 11	18 10	18 9	18 8
15	16 8	16 7	16 6	16 5	18 20	18 19	18 18	18 17
17	16 16	16 15	16 14	16 13	18 29	18 28	18 27	18 26
19	16 25	16 24	16 23	16 22	18 38	18 37	18 36	18 35
21	16 34	16 33	16 31	16 30	18 47	18 45	18 44	18 43
23	16 43	16 41	16 40	16 39	18 56	18 54	18 53	18 52
25	16 51	16 50	16 49	16 48	19 4	19 3	19 2	19 1
27	17 0	16 59	16 58	16 56	19 13	19 12	19 11	19 10
29	17 9	17 8	17 6	17 5	19 22	19 20	19 20	19 19

The uſe of the former Tables.

The uſe of theſe Tables is twofold;

Firſt, They direct us to finde at what hour and min. any of the Stars in the firſt Table, will be upon the Meridian, or South-point; or ſeeing them upon the Meridian, they tell you exactly the hour of the Night.

Secondly, They ſhew at what hour and min. any of the ſaid Stars riſe or ſet; and therefore ſeeing any of them, either in the Eaſt or Weſt Horizon, you may readily thereby know the true hour of the Night. And becauſe the uſe hereof is of good conſequence, I ſhall make further illuſtration thereof.

Therefore if the ſouthing be inquired, ſeek (in the ſecond Table) the *Right Aſcenſion* of the Star, from which ſubſtract the Suns *Right Aſcenſion*, (found in the ſecond Table) and the remainer will be the time of Southing: therefore ſeeing any of them on the Meridian, or ſouth point, as one or other of them is in it, or neer it at all times) you may thence preſently know the hour by obſerving the premiſes

Examples. Suppoſe that upon the 15th of *October*, early in the morning, I ſhou'd eſpy the *Pleiades*, or ſeven *Stars*, upon the Meridian or ſouth point, and from thence would know the true hour of the night, wherefore I ſeek the *Right Aſcenſion* of the ſeven *Stars*, in the firſt Table, which is 3 hours 28 min. and the Right Aſcenſion of the Sun in the ſecond Table, which (the 15th of *October* this year 1664) is 14 ho. 2 min. and becauſe ſubſtraction cannot be made, I add to the right aſcenſion of the ſeven *Stars* 24 hours; and from the ſumm 27 ho. 28 min. I deduct the Suns right aſcenſion and the reſidue is 13 ho. 26 min. from which taking 12, there remains

1 hour 26 min. in the morning, for the true hour of the night, or time of the ſeven *Stars* coming to the ſouth the ſaid 15th of *October*, which is (in a manner) the ſame in the years 1660, 1664, 1668, 1672, and 1676; yea, and that neer enough for every Quaternarie of years till 1700.

Again, If the riſing and ſetting be required, you muſt (by the Table) find the ſemidiurnal Arch, which if you ſubſtract from the time of ſouthing, it gives you the time of the riſing, but adding it thereto, it ſhews the time of ſetting.

Suppoſe therefore the ſame day you deſire to know when the ſeven *Stars* riſe and ſet; ſeek therefore their ſemidiurnal Arch, which you ſhall finde in the Table 8 ho. 16. min: which being ſubſtracted from the time of ſouthing 13 ho. 26 min. leaveth the time of their riſing at 5 ho. 10 min. at night; but adding them together, it giveth the time of their ſetting at 9 hours and 42 min. the next morning: Therefore in caſe you ſhould ſee the ſeven *Stars* riſing that night, you may conclude it to be 10 min. paſt 5 a Clock at night; but if you ſhould ſee them (in the Eaſt) an hour high, it is 10 min. paſt 6, if 2 ho. high, then it is 10 min. paſt 7, if 3 ho. high, 10 min. paſt 8, *&c.*

The

The Poſtſcript.

IN *the Sixth Book of the preceding* Treatiſe (*to which the five former are ſubſervient*) *I have in as briefe and plain a Method as I could, ſhewed exactly how to Meaſure, Reduce, and divide all kinde of Lands whatſoever, by the* Geometricall *or* Plain Table; *and how thereby, to take the true* Plot, Map, *and* Symmetry *of a whole* Mannour, *or* Lordſhip; *and to expreſs every particular* Ground, Houſe, Homſted, River, Street, Lane, High-way, Mill, Grove *of* Trees, Lake, Pond, Spring, *or whatever elſe ſhall be contained therein, according to their true ſite and ſtanding within the* Lordſhip: *and to divide, take in, or incloſe the ſame, according to the moſt ſubſtantiall wayes of Art. Whereunto is added* (*as a thing neceſſary for every* Surveyor) *moſt perfect and eaſie* Rules *for taking the exact Dimenſion of all manner of* Superficies *and* Solids, *as* Walls, Tyling, Boards, Glaſs, Tapiſtry, Hangings, Wainſcot, Cielings, Pavement, Timber, Stone, *and the like; of what forme, faſhion, or proportion ſoever. Neither have I been wanting, in the two following Books, to deliver ſuch things as are uſefull to be known of every*

Surveyor, *to which end we have inserted certain easie and perfect* Rules, *to take the just Altitude or height, of any* Tower, Steeple, Turret, Tree, *or other thing, either accessible, or inaccessible, severall wayes; and to finde the true distance of any place from you, whether it be within sight or not: To which, in the tenth and last Book, we have subjoyned many easie Rules and Tables, as well* Astronomicall, *as* Horologiographicall, *variously performed* Problematically; *which doubtless will yield matter of delight and recreation to the ingenuous* Surveyor; *yea, and to every* Artificer, *and* Tradesman *in generall, who (no doubt) shall also finde abundance of profit, in the reading and practicing thereof: Lastly, I here thought good to admonish my* Readers, *that whereas, in the sixth Book, we have (for brevity sake, and for fear of overburdening you with varieties) shewed how to perform, and accomplish any* Work *of* Plotting Land *by the* Table *alone, as being the most absolute of all other Instruments: yet such as desire to effect the same by the* Theodelite, Circumferentor, *or* Peractor, *shall (to their great content) finde the use of them, plentifully taught, by my loving Friend Mr.* William Leybourn, *in his* Compleat Surveyor, *Printed in Folio,* 1657; *for Mr.* George Sawbridg, *at the* Bible *on* Ludgate-Hill: *wherein he hath ingeniously,* (Artist-*like*) *handled the same, to his exceeding commendation, to which* Book *I refer you.*

Many other Instruments have been devised for

Land-

Land-Measure, *the* Sector, Cress-Staff, Topographicall-Gl[illegible], Pandoron, Geodeticall-Staff, *&c. which though they were all, or most of them, wittily contrived, and are of good use, yet upon practise, you shall find the very best of them much inferiour, and not to be compared with the* Plain-Table: *and therefore was, that in the former* Treatise *I have alone treated thereof. Thus wishing you success, in all your best Studies and Undertakings, I rest a Friend to you and all that are* Mathematically *affected.*

Vincent Wing.

Ab Ædibus nostris L[illegible]
fenhamiæ, *die* 19°.
Januarii, 1664.

FINIS.